CELESTIAL OBJECTS

LONDON: PRINTED BY
SPOTTISWOODE AND CO., NEW-STREET SQUARE
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CELESTIAL OBJECTS

FOR COMMON TELESCOPES

BY THE REV. T. W. WEBB, M.A. F.R.A.S.

VICAR OF HARDWICK, HEREFORDSHIRE

THIRD EDITION, REVISED AND ENLARGED

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Many things, deemed invisible to secondary instruments, are plain enough to one who 'knows how to see them' SMYTH

When an object is once discovered by a superior power, an inferior one will suffice to see it afterwards SIR W. HERSCHEL

Inertia mors est philosophiæ—vivamus nos et exerceamur

KEPLER

To the Memory of

THE LATE VICE-ADMIRAL W. H. SMYTH

K.S.F. D.C.L. F.R.S. ETC.

IN DUE ACKNOWLEDGMENT OF INDISPENSABLE ASSISTANCE

DERIVED FROM HIS MOST VALUABLE

CYCLE OF CELESTIAL OBJECTS

The Third Edition of this little Work

IS RESPECTFULLY AND GRATEFULLY INSCRIBED

BY

THE AUTHOR

cient for the student's purpose are far less expensive than formerly ; a trifling outlay will often procure them, of excellent quality, at second-hand ; and many are only waiting to be called into action. But a serious obstacle remains to the inexperienced possessor. How is he to use his telescope in a really improving way? What is he to look for? And how is he to look for it? For want of an answer many a good instrument is employed in a desultory and uninstructive manner, or consigned to dust and inactivity.

Materials for his guidance exist, indeed, in profusion, but some of them are difficult of access ; some, not easy of interpretation ; some, fragmentary and incomplete : and the student would find it a discouraging task to reduce them into a serviceable form. This, then, is what has been attempted for him in the following pages, by one who, during many years, would have rejoiced to avail himself of some such assistance, if he had known where to meet with it, and who does not know where it is to be met with, in a convenient shape, to the present day.

For the more advanced observer, the 'Cycle of Celestial Objects,' published in 1844 by Captain, now Vice-Admiral Smyth, will be found a treasury of varied information, and of the highest value as the companion

of a first-rate telescope: but its very superiority, to say nothing of its bulk and cost, renders it more suitable for his purpose, than for those humble beginnings which are now in view. It has, however, been of the most essential service in the preparation of the present undertaking, which without it would, in all probability, never have seen the light, and which, as far as the sidereal portion of it is concerned, is based upon it as the standard authority.

Nothing would have been easier than, on so fertile a subject, to have expanded this treatise to a much larger bulk: but it would thus, in some measure, have defeated its own object. In order therefore to reduce the size of the volume, without omitting such details as may seem to be required by the present state of Astronomy, the reader will have to excuse a condensed mode of expression, the result of necessity rather than of choice; and, as considerable pains have been taken in the verification of facts, a general list of authorities will supersede references at the foot of the page.

Limited in extent, imperfect in execution, and in parts only suggestive in character, this little book may perhaps serve as a foundation, on which students of astronomy may raise the superstructure of their own experience; and in that case the author's intention will

be fulfilled. He will be especially gratified, if his endeavour to remove some difficulties may tend to increase the number of those who 'consider the heavens.' For he is convinced that in such a personal examination of their wonders will be found an interesting and delightful pursuit, diversifying agreeably and instructively the leisure hour, and capable of a truly valuable application, as leading to the most impressive thoughts of the littleness of man, and of the unspeakable greatness and glory of the CREATOR. To such a study, the impressive words of the late Sir R. H. Inglis may be most suitably applied: 'Every advance in our knowledge of the natural world will, if rightly directed by the spirit of true humility, and with a prayer for GOD's blessing, advance us in our knowledge of Himself, and will prepare us to receive His revelation of His Will with profounder reverence.'*

* Report of British Association, 1847.

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TO

THE SECOND EDITION.

The circumstances referred to in the foregoing Introduction are in part materially altered. The 'Cycle of Celestial Objects' has for some time been out of print; and this little treatise, which might have served as a stepping-stone to it, no longer stands alone as a familiar guide to the inexperienced observer. Since, however, a renewed impression has been thought desirable, it could not suitably appear without an attempt to adapt it to the existing condition of science. Eight years of astronomical discovery and optical improvement have occasioned a necessity for some modifications and many additions, the most important of which are an enlargement of the list of Double Stars and Nebulæ, and its extension, for the use of amateur observers in our colonies, to the whole of the Southern heavens. The omission of position-angles has also been supplied. A comparative table of star-magnitudes, an alphabetical list of lunar names, and an index in order of Right Ascension to the sidereal part, will, it is hoped, be found useful; and a general endeavour has been made to bring the work up more nearly to the requirements of students at the present day.

For many important corrections and improvements the writer is indebted to friends, to whom he would take this opportunity of acknowledging his deep obligation. In referring especially to the names of Dawes,* Knott, Birt, and Baxendell, he feels that he is not only discharging a debt of gratitude, but acquiring for his little treatise a sanction, the value of which the intelligent reader will be at no loss to appreciate.

* This acknowledgment can now, while this sheet is passing through the press, be made only to the honoured and cherished memory of one of the most eminent of observers, and kindest of friends. (March 2, 1868.)

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TO

THE THIRD EDITION.

THE SECOND impression of this little work having been for a considerable time exhausted, another is now offered to the student, with such additions as may render it more accordant with the present state of science. The lunar map has been much enriched by the kindness of Mr. Birt, to whom, as to other friends, renewed acknowledgments are due for valuable suggestions and efficient aid. The omission of a few objects of inferior interest from the sidereal part has been more than compensated by the incorporation of nearly 70 fresh ones; and the Declinations now added to the Right Ascension Index will be found convenient. The most recent information, especially as regards the planet Venus, is embodied in an Appendix (No. I.), which has in part grown out of the great but in the present instance unavoidable delay, attendant on the preparation of this edition.

AUTHORITIES.

Annals of Harvard College Observatory.
Annuaire du Bureau des Longitudes.
Astronomical Register.
Astronomisches Jahrbuch.
Astronomische Nachrichten.
Beer and Mädler, Der Mond.
——— Beiträge, &c.
Bianchini, Hesperi et Phosphori, &c.
Bond, Account of Donati's Comet.
Breen, Planetary Worlds.
British Association Catalogue.
Carrington, Observations of the Spots on the Sun.
Comptes Rendus.
De La Rue, Stewart, and Loewy, Researches on Solar Physics.
Donati, Essay on Comets.
Engelmann, Jupiterstrabanten.
English Mechanic.
Gould, Astronomical Journal (American).
Gruithuisen, Naturgeschichte, &c.
——— Neue Analekten.
Herschel, Observations at Cape of Good Hope.
——— Outlines of Astronomy.
Hevelius, Selenographia.
Hind, Solar System.
——— The Comets.
Histoire de l'Académie.
Hooke, Posthumous Works.
Humboldt, Cosmos.
Huygens, Systema Saturnium.
Kepler, Opera.
Lohrmann, Topographie, &c.
Memoirs of Royal Astronomical Society.
——— American Academy.
Memorie del Collegio Romano.
Monthly Notices of R. Astron. Society.
Nature.
Nautical Almanac.
Philosophical Transactions.
Proctor, The Sun, &c.
Reports of British Association.
Schmidt, Resultate, &c.
——— Der Mond.
——— Rillen auf dem Monde.
Schröter, Selenotopographische Fragmente.
——— Aphroditographische ditto.
——— Beobachtungen über den Cometen von 1807.
——— Ditto, 1811.
Smyth, Cycle of Celestial Objects.
——— Ædes Hartwellianæ.
——— Speculum Hartwellianum.
Smyth, C. Piazzi, Astronomical Observations, Edinburgh.
Struve, Mensuræ Micrometricæ.
——— Positiones Mediæ.

Pulchra sunt omnia, faciente Te, et ecce Tu inenarrabiliter pulchrior, qui fecisti omnia.

ST. AUGUSTINE

CONTENTS.

CELESTIAL OBJECTS.

PART I.

THE INSTRUMENT AND THE OBSERVER.

O multiscium et quovis sceptro pretiosius Perspicillum! an, qui te dextra tenet, ille non rex, non dominus constituatur operum Dei? Vere tu
Quod supra caput est, magnos cum motibus orbes
Subjicis ingenio.—KEPLER.

THE TELESCOPE.

ALTHOUGH the professed design of this volume is to provide a list of objects for common telescopes, it may not be out of place to premise a few remarks upon the instruments so designated.

By 'common telescopes' are here intended such as are most frequently met with in private hands; achromatics of various lengths up to 5 or 6 feet, with apertures* up to 3 or 4 inches; or reflectors of somewhat larger diameter, but in consequence of the loss of light in reflection, not greater brightness.† The original observations in the following pages

* 'Aperture' always means the clear space which receives the light of the object; the diameter of the object-glass in achromatics, or the large speculum in reflectors, exclusive of its setting.

† Maskelyne estimated the apertures of reflectors and achromatics of equal brightness as 8 to 5. Dawes gives this value for Gregorians, but like Herschel II. rates Newtonians as 7 to 5. Steinheil has ascribed much more light to achromatics. Arago strangely asserted that none

were for the most part made with such an instrument, an achromatic by the younger Tulley, $5\frac{1}{2}$ feet in focal length,* with an aperture of $3\frac{7}{10}$ inches, and of fair defining power; smaller instruments of course will do less, especially with faint objects, but are often very perfect and distinct: and even diminutive glasses, if good, are not to be despised; they will shew *something* never seen without them. I have a little hand telescope, $22\frac{1}{4}$ inches long when fully drawn out, with an object-glass of about 14 inches focus, and $1\frac{1}{3}$ inch aperture: this, with an astronomical eye-piece, will shew the *existence* of the solar spots, the mountains in the Moon, Jupiter's satellites, and Saturn's ring. Achromatics of larger dimensions have become much less expensive than formerly, and silvered specula of considerable size are now comparatively common; even for these it is hoped that this treatise, embodying some of the results of the finest instruments, may not be found an inadequate companion as far as it goes.

In judging of a telescope, we must not be led by appearances. Inferior articles may be showily got up, and the outside must go for nothing. Nor is the clearness of the glass, or the polish of the mirror, any sign of excellence: these may exist with bad 'figure' (*i.e.* irregular curvature), or bad com-

was lost in them. The silver-on-glass specula, invented by Foucault and Steinheil, and now manufactured in England, take their place between the metal Newtonian and the achromatic, approaching more nearly to the latter, especially when the plane mirror is replaced by a prism (which, however, does not always conduce to critical definition). Buffham assigns equal light to silvered Newtonians of 9, $6\frac{1}{2}$, and $4\frac{1}{2}$, and achromatics of 8, $5\frac{3}{4}$, and 4 inches respectively.

* The focal length is measured from the object-glass, or speculum, to the spot where the rays cross and form a picture of the sun or any celestial body.

bination of curves, and the inevitable consequence, bad performance. We need not regard bubbles, sand-holes, scratches, in object-glass or speculum; they merely obstruct a very little light. Actual performance is the only adequate test. The image should be neat and well defined with the highest power, and should come in and out of focus sharply; that is, become indistinct by a very slight motion on either side of it. A proper test-object must be chosen; the Moon is too easy; Venus too severe except for first-rate glasses; large stars have too much glare; Jupiter or Saturn are far better; a close double star is best of all for an experienced eye; but for general purposes a moderate sized star will suffice; its image, in focus, with the highest power, should be a very small disc, almost a point, accurately round, without 'wings,' or rays, or mistiness, or false images, or appendages, except one or two narrow rings of light, regularly circular, and concentric with the image;* and in an uniformly dark field; a slight displacement of the focus either way should enlarge the disc into a luminous circle. If this circle is irregular in outline, or much brighter or fainter towards the centre,† or much better defined on one side of the focus than the other, the telescope

* The real diameter of a star in the telescope would be inconceivably small. The apparent or 'spurious' disc, and rings, result from the undulatory nature of light. They seem, however, to be somewhat affected by atmospheric causes. Herschel II. speaks of nights of extraordinary distinctness, in which '*the rings are but traces of rings*, all their light being absorbed into the discs.' I have entered 1852, March 23, as 'a very fine night, though the rings and appendages around the brighter stars were rather troublesome;' 1852, April 1, 'an exceedingly fine night at first, with scarcely a trace of rings or appendages.' See also the star 70 Ophiuchi, in the following catalogue.

† The small mirror in a Newtonian causes a central darkness out of the focus, which should be nearly the same on either side of it.

may be serviceable, but is not of high excellence. The chances are many, however, against any given night being fine enough for such a purpose, and a fair judgment may be made by day from the figures on a watch-face, or a minute white circle on a black ground, or a thermometer bulb in the sunshine, placed as far off as is convenient. An achromatic, notwithstanding the derivation of its name, will shew colour under high powers where there is a great contrast of light and darkness. This 'outstanding' or uncorrected colour results from the want of a perfect balance between the optical properties of the two kinds of glass of which the object-glass is constructed: it cannot be remedied, but it ought not to be obtrusive. In the best instruments it forms a fringe of violet, purple, or blue, round luminous objects in focus under high powers, especially Venus in a dark sky. A red or yellow border would be bad; but before condemning an instrument from such a cause, several eye-pieces should be tried, as the fault might lie there, and be easily and cheaply remedied. Reflectors are most pleasantly exempt from this defect; and as now made by With, and mounted by Browning in the Newtonian form, with specula of silvered glass, well deserve, from their cheapness, combined with admirable defining power, to regain much of the preference which has of late years been accorded to achromatics. The horizontal view of objects at all altitudes is extremely pleasant, when once a little experience has been gained in finding and following: the same advantage, however, attends the use of a diagonal eye-piece with the achromatic. The chief disadvantage of reflectors is the greater aperture, and consequently greater atmospheric disturbance, corresponding with the same amount of light.

The eye-piece, or ocular, is only a kind of microscope,

magnifying the image formed in the focus of the object-glass or speculum. The size of this image being in proportion to its distance from the glass or mirror which forms it, the power of the same eye-piece in different telescopes varies with the focal length. Hence one disadvantage of a short telescope; to get high powers, we must employ minute and deeply-curved lenses, which are much less pleasant in use: with a telescope twice as long, half the depth in the eye-piece produces an equal power. The focal picture, as in the camera, is always inverted, and so in the astronomical eye-piece it remains.* For terrestrial purposes it is erected by two additional lenses; but a loss of light is thus incurred, and as the inversion of celestial objects is unimportant, erecting eye-pieces (always the longest of a set) should never be employed for astronomy; the eye soon becomes accustomed to the inverted picture, and the hand to the reversed motion in following the object. The lateral vision in the Newtonian reflector interposes another difficulty, easily mastered, however, by practice; the true position of the object being always known from the direction of its motion through the field. A multitude of eye-pieces is needless, but three at least are desirable; one with low power and large field, for extended groups of stars, nebulæ, and comets, supplying also, if necessary, the place of a 'finder' for deeper magnifiers; a stronger one for general purposes, especially the moon and planets; and a third, as powerful as the telescope will bear, for minuter objects, especially double stars. A greater number of eye-pieces admits, how-

* It is erect in the Galilean eye-piece and the Gregorian reflector. But the use of the former is almost confined to opera-glasses, as its field with high powers is exceedingly small; and the latter is an inferior construction, and now little employed.

ever, of what is often important, an adaptation of the power to the brightness of the object. Ordinary astronomical eye-pieces are shorter in proportion to their power. It is a better plan to change them by means of a short tube, or 'adapter,' than by a screw; in which case they are more liable to be dropped and injured. The power may be much increased by unscrewing and taking away the 'field-lens,'—that furthest from the eye; but the field will be very imperfect, excepting near its centre. The highest powers of large telescopes are often made thus, with single lenses, but the convex face of the lens is then turned towards the eye, as it gives sharper vision. Sir W. Herschel used the double convex form, having shallower curves. The common kind, with two lenses, having the flat side of each next the eye, is called the Huygenian or negative eye-piece: the positive or Ramsden eye-piece has a flatter field, but is not, like the other, achromatic. The interposition of a combination called a Barlow lens raises the power with little loss of light; and as one will suit all the eye-pieces, it doubles the set at a small expense. The silvered specula mounted by Browning are provided with achromatic eye-pieces of peculiar construction and great excellence.

If the power of our oculars has not been engraved upon them,* we may get a fair approximation to it by viewing an equally divided scale at a distance (for low powers, a brick wall will answer) with one eye through the telescope, and with the other alongside of it, and noting how many unmagnified divi-

* These figures are not, however, always to be depended upon, and never, if the eye-piece was made for an instrument of a different focal length. The celebrated Short exaggerated the powers of his reflectors: and those of the great achromatics of Dorpat and Berlin were found by Struve and Encke to be overrated.

sions are covered by a single magnified image. Or, better still, we may have recourse to the Berthon Power-gauge, a little apparatus, the simple, efficient, and inexpensive character of which entitles it to very warm commendation.*

The test of excellence in separating power has been fixed by Dawes at the quotient, expressed in seconds, of 4·56 divided by aperture in inches. Thus a 10-inch object-glass or speculum ought to separate double stars at 0″·456 of distance between their centres. This value practically concurs with those given by Dallmeyer and Alvan Clark. Reflectors somewhat surpass achromatics in this respect, as theoretically they ought to do: but they are apt to be more troubled by rings and scattered light. The best telescopes of either kind will bear a power of 100 per inch of aperture on stars: for planets, half that power will usually more than suffice.

An object-glass of inferior defining power may sometimes be improved by stopping out defects, or contracting the aperture. Streaks or specks of unequal density are very injurious: they may be detected by turning the telescope to a bright light, taking out the eye-piece, and placing the eye in the focus; every irregularity will then be visible in the illumination which overspreads the object-glass; and, if of small extent, may be stopped out by a bit of sticking-plaster. If the performance is not thus improved, try a contracted aperture: make a cap of pasteboard fitting over the object-glass like the usual brass cap, but with a circular opening a little less than the clear aperture;—if the indistinctness is thus diminished but not removed, try several discs of pasteboard placed successively within this cap, with progressively contracted openings, till distinct vision is obtained; there we must stop, or valuable

* It may be purchased for 7*s*. 6*d*. of Mr. Tuck, watchmaker, Romsey.

light will be lost. An excentric opening in the pasteboard cap may sometimes be serviceable, being turned round the axis so as to conceal different parts of the glass or mirror, till the best effect is produced: in other cases, a central pasteboard disc, supported by narrow arms from the sides, and leaving an open ring of light all round, may be tried. But for comets or nebulæ, it will be best to restore the original aperture, as with faint and ill-defined objects light is more essential than distinctness. To see whether the smaller speculum which stands in the mouth of a reflector is rightly centered, take out the eye-piece, and look at the small speculum; in it will be seen an image of the large mirror, with the small speculum reflected again upon it: these images should be concentric with the small speculum; if not, a cautious alternate loosening and tightening of the three little screws at the back of the small speculum will bring all right.

A good stand is essential: if unsteady, it will spoil the most distinct performance; if awkward, it will annoy the observer; if limited in range, it may disappoint him at some interesting juncture. It may be well left to a respectable optician; but where expense is a serious consideration, a little mechanical ingenuity and knowledge of such contrivances will devise one which will answer sufficiently. The old arrangement, with a vertical and horizontal, or 'altitude and azimuth' motion, is simple and manageable: the equatorial form, which makes the telescope revolve on an axis parallel to that of the earth, has some great advantages, in following the object by a single motion, and where the expense of divided circles and spirit-levels is admissible, in finding planets and bright stars by day, and identifying minute objects by night: but, to do its work, it must be placed accurately in the meridian, and out of that

position has little advantage. In any case, if the stand is to be moveable, let it be strong enough for steadiness without being too heavy for portability.*

A sidereal clock is often considered a necessary adjunct to an equatorial mounting, in order to find objects invisible to the naked eye. But it may be dispensed with by the following method of 'differentiation' in all cases, excepting during the brief season of twilight, when neither sun nor stars can be employed. Write down the difference of Right Ascension (taking particular notice whether additive or subtractive) between the required and some known object—the sun by day, a neighbouring bright star by night. Seek the known object by the finder, and place it in the centre of your largest field : clamp the R. A. circle : set the telescope to the declination of the object sought, and clamp it there : unclamp in R. A. and move the telescope E. or W. as the case requires, to the value of the ascertained difference in R. A. and the object will be found in the field, somewhat W. of the centre, by a distance dependent on the duration of the process.

An observatory is by no means essential, but it would be difficult to over-estimate its advantage in point of comfort as well as economy of time. It used to be an expensive luxury; but a very simple and cheap 'telescope-house,' combining shelter with open-air freedom, to the great merit of which I can bear full testimony, has been devised by the Rev. E. L. Berthon, and is described in the *English Mechanic*, October 13 and 20, 1871.

We will close this section with the encouraging words of the Council of the Royal Astronomical Society, in their

* A very cheap equatorial stand is described in 'Astron. Register,' xiv. 35.

Report for 1828. 'Everyone who possesses an instrument, whose claims rise even not above a humble mediocrity, has it in his power to chalk out for himself a useful and honourable line of occupation for leisure hours, in which his labour shall be really valuable, if duly registered; . . . those who possess *good* instruments, have a field absolutely boundless for their exertions.'

THE MODE OF OBSERVATION.

An ordinary telescope may be easily prepared for use: to fix it on its stand; to point it by means of the finder; to adjust the focus to the eye (remembering that different eyes require different adjustments), are processes scarcely requiring instruction. But many mistakes may be made in detail; and in this, as in everything else, there are various methods of doing the thing the wrong way. The present section will, therefore, consist of negative rather than positive directions, pointing out rather what should be avoided than what should be done.

1. Do not begin by fixing the telescope in a warm room and opening the window. A boarded floor is bad, as every movement of the observer is liable to produce a tremor; but the mixture of warm and cool currents at the window is worse; it is an artificial production of the fluttering and wavering which, as naturally existing in the atmosphere, are such an annoyance to astronomers. If a window must be used, let it be opened as long beforehand as may be, and let the object-glass be pushed as far as possible outside; there should be no fire in the room; and any other windows, as well as the door, should be shut before beginning to observe: the nuisance may

thus be sometimes abated; but the right place is unquestionably out of doors.

2. Do not wipe the object-glass or speculum* more than can possibly be helped. Hard as the materials are, scratching is a very easy process; and the ultimate result of ordinary wiping may be seen in an old spectacle-glass held in the sunshine. The most valuable part of a good telescope deserves much more careful treatment; and, if protected from dust and damp, it will very seldom require to be touched. Nothing but great carelessness would expose it to dust: and the dewing of the surface may be almost always avoided. The object-glass or speculum, if kept in a cold place, should not be uncovered, if possible, in a warmer air till it has gained something of its temperature; and it must be invariably closed up in the air in which it has been used before it is removed in-doors; or, in either case, it may be dewed like a glass of cold water brought into a heated room. The object-glass, however, being much exposed to radiation, requires additional protection; and this may be easily contrived. A tube of tin, or pasteboard, or very thin wood, such as is used for hat-boxes, fitting on to the place whence the brass cap has been removed, and three or four times longer than wide, will, in general, keep the object-glass bright. This 'dew-cap' must fit tight enough to stand firm, or it will bend down and intercept the light; but not so tight as to cause trouble in removing it to put on the brass cap in the open air. It is better to blacken its interior—indeed, necessary, if of tin; this may be done with lamp-black mixed with size or varnish, so as neither to shew a gloss nor rub off; or a piece of black cloth or velvet may be glued or pasted inside it. A dew-cap

* The following remarks apply to metallic specula only.

on the finder will often save much trouble. Should it be necessary to leave the telescope for some time in the cold, a clean handkerchief thrown over the end of the dew-cap will be a complete safeguard. Should an object-glass or speculum become damped after all, do not close it up in that state; if the cloud of dew is very slight, it may quite disappear in a warm room, especially if exposed to a fire; if dense, however, it may leave a stain which ought to be quickly removed, as well as any little specks of dirt or dulness which will form, one knows not how. To do this, dust the surface first with a soft camel's hair pencil or varnishing brush, which will remove loose particles; then use, very cautiously, a very soft and even piece of chamois leather, which has not been employed for any other purpose, and must be always kept in a wide-mouthed stoppered bottle or wrapped up from dust; or a very soft silk handkerchief (which Lassell uses for glass) preserved with similar care. But the wiping must be as gentle as possible; hard rubbing would certainly damage a speculum, and do no good to an object-glass. Any refractory stains may be breathed upon, or touched with pure alcohol, and wiped till dry: but if the glass has become discoloured, we must put up with the defect; and care should be taken not to mistake specks in the substance of the glass for foreign matters lodged on its surface. A slight tarnish may frequently be removed from a speculum by lemon-juice, or a solution of citric acid, carefully wiped off in a short time: if this does not restore its brightness, it is better to leave it alone; a slight loss of light is not so great an injury as would result from strong friction. The taking out or replacing of an object-glass or mirror is a delicate operation, and hurry or carelessness may easily make it a very dangerous one; speculum metal is nearly as brittle

as glass: but this material is rapidly going out of use, from the superiority of the silver-on-glass mirrors, which are now becoming appreciated as they deserve. The management of these need not be described here, as special instructions should always accompany them.

Dimness of vision often results from damp on the eye-lens. This will rapidly disappear, without wiping, in a warmer temperature. If the finder does not act well, this may be suspected to be the cause. For these and similar reasons, a small lamp, the light of which can be concealed when not wanted, is a convenient adjunct to the telescope: any glass surface held at a safe height over it will speedily be cleared of moisture.

Eye-piece lenses require occasional wiping; the leather may be pressed to their edges with a bit of soft wood. Their flat faces are easily scratched if laid downwards on a table. The screws demand very gentle usage: a previous turn backwards, before screwing in, causes the thread to fall with a snap into its place.

Brass-work should not be rubbed with polishing powder, which might injure the lacquering.

3. If the telescope does not seem altogether right, notwithstanding all the pains you can take in bringing it to focus, do not meddle with screws or adjustments, unless you thoroughly understand the construction, or can obtain good directions. You may centre the small speculum of a reflector with safety, but in most cases a screw-driver is a dangerous tool in inexperienced hands.

4. Do not use any part of a telescope or stand roughly, or expose it to any blow or strain. It is a delicate instrument, and well deserves careful preservation.

5. Do not spare trouble in adjusting the focus. It is well known that different eyes require a change, sometimes a great one; and the same observer's focus is not invariable, being affected by the temperature of the tube and the state of the eye, the adjustment of which, as Dawes has pointed out, shortens with intense gazing, and is apt to vary with the relative brightnesses of objects, besides being, to a certain extent, under the observer's control.

6. Do not over-press magnifying power. Schröter long ago warned observers against this natural practice, which is likely to lead beginners into mistakes. A certain proportion of *light* to *size* in the image is essential to distinctness; and though by using a deeper eye-piece we can readily enlarge the size, we cannot increase the light so long as the aperture is unchanged; while by higher magnifying we make the inevitable imperfection of the telescope and atmosphere more visible. Hence the picture becomes dim and indistinct, beyond a certain limit, varying with the brightness of the object, the goodness of the telescope, and the steadiness of the air. Comets and nebulæ, generally speaking, will bear but little magnifying. For the moon and planets, the power should be high enough (if the weather is suitable) to take off the glare, low enough to preserve sufficient brightness and sharpness: the latter condition being preserved, minute details are likely to come out better with an increase of power. Stars bear much more magnifying, from their intrinsic brilliancy; and they are enlarged very slightly in proportion: their images ought never, with any power, to exceed the dimensions of minute discs,—*spurious discs*, as they are termed, arising from the undulatory nature of light, and usually smallest in the best telescopes. A very high power has, however, so many disadvantages, in

the difficulty of finding and keeping the object, the contraction of the field, the rapid motion of the image (in reality, the magnified motion of the earth), and the exaggeration of every defect in the telescope, the stand, and the atmosphere, that the student will soon learn to reserve it for special objects and for the finest weather, when it will sometimes tell admirably. A very low power is apt to surround bright objects with irradiation, or glare. Experience in all these matters is the surest guide.

It may be very useful to know the diameter of the field of each of our eye-pieces. This may be obtained from the time which an object in or very near the equator takes in passing *centrally* through it: any star having but little declination will answer (γ *Virginis* and δ *Orionis* may be especially mentioned), or the moon or a planet in a corresponding position. Several trials may be made, and the mean result in minutes and seconds of time multiplied by 15 will give the diameter of the field in minutes and seconds of arc, or space.

7. Do not be dissatisfied with first impressions. When people have been told that a telescope magnifies 200 or 300 times, they are often disappointed at not seeing the object larger. In viewing Jupiter in opposition with a power of only 100, they will not believe that he appears between two and three times as large as the moon to the naked eye; yet it is demonstrably so. There may be various causes for this illusion; —want of practice,—of *sky-room*, so to speak,—of a standard of comparison. A similar disappointment is frequently felt in the first impression of very large buildings; St. Peter's at Rome is a well-known instance. If an obstinate doubt remains, it may be dissipated for ever when a large planet is near enough to the moon to admit of both being

seen at once, the planet through the telescope, the moon with the naked eye.

8. Do not lose time in looking for objects under unfavourable circumstances. A very brilliant night is often worthless for planets or double stars, from its blurred or tremulous definition; it will serve, however, for grand general views of bright groups or rich fields, or for irresolvable nebulæ, which have no outlines to be deranged: a hazy or foggy night will blot out nebulæ and minute stars, but sometimes defines bright objects admirably; never condemn such a night untried. Twilight and moonlight* are often advantageous, from the diminution of irradiation. Look for nothing near the horizon; unless, indeed, it never rises much above it; nor over, or to the leeward of a chimney *in use*, unless you wish to study the effect of a current of heated air. If you catch a really favourable night, with sharp and steady vision, make the most of it; you will not find too many of them. Smyth, who thinks our climate has been unfairly depreciated, says, 'where a person will look out for opportunities in the mornings as well as evenings, and especially between midnight and daybreak, he will find that nearly half the nights in the year may be observed in, and of these sixty or seventy may be expected to be splendid.' But ordinary students must of course take their chance, with their fewer opportunities. With due precaution,† nothing need be feared from 'night-air:' that prejudice is fully confuted by the well-known longevity of astronomers, even of such as have habitually protracted their watchings

'Till the dappled dawn doth rise.'

* Secchi has found the detail of the Great Nebula in Orion much more visible in moonlight.

† A wadded dressing-gown has been strongly recommended.

9. In examining faint objects, do not prepare the eye for seeing nothing, by dazzling it immediately beforehand with a lamp, or white paper. Give it a little previous rest in the dark, if you wish it to do its best.*

10. When a very minute star or faint nebula is not to be seen at once, do not give it up without trying *oblique* or *averted vision*, turning the eye towards the edge of the field, but keeping the attention fixed on the centre, where the object ought to appear; this device, with which astronomers are familiar, is often successful; its principle depends probably on the greater sensitiveness of the sides of the retina.

11. Do not avoid the trouble of recording regularly all you see, under the impression that it is of no use. If it has no other good effect, it tends to form a valuable habit of accuracy; and you might find it of unexpected importance. And, like old Schröter, *trust nothing to memory*. If there has been haste —and sometimes if there has not—it is surprising what unforeseen doubts may arise the next day: make at least rough notes at the time, and reduce them speedily into form, before you forget their meaning.

12. Do not be discouraged by ignorance of drawing from attempting to represent what you see. Everybody ought to be able to draw; it is the education of the eye, and greatly increases its capacity and correctness: but even a rough sketch may have its use; taken on the spot, it will not be all untrue; it may secure something worth preserving, and lead to further improvement.

In conclusion, may I be permitted to remind the young

* Herschel II., when about to verify his father's observations on the satellites of Uranus, prepared his eye with excellent effect, by keeping it in utter darkness for a quarter of an hour.

observer, not to lose sight of the immediate relation between the wonderful and beautiful scenes which will be opened to his gaze, and the great Author of their existence? In looking upon a splendid painting, we naturally refer its excellence to the talent of the artist; in admiring an ingenious piece of mechanism, we cannot think of it as separate from the resources and skill of its designer; still less should we disconnect these magnificent and perfect creations, so far transcending every imaginable work of art, from the remembrance of the Wisdom which devised them, and the Power which called them into being. Such is eminently the right use of the Telescope —as an instrument, not of mere amusement or curiosity, but of a more extensive knowledge of the works of the Almighty. So new an aspect as has thus been given to the material universe—so amazing a disclosure as has thus been permitted to man, of the vastness of his Maker's dominion—can hardly be ascribed to blind accident or human contrivance: in thus employing Galileo's invention, we may well feel his grateful acknowledgment, that it was the result of the 'previous illumination of the Divine favour,'* to have been not only beautiful, but true.

* Divina prius illuminante gratia.

PART II.

THE SOLAR SYSTEM.

O domus luminosa et speciosa, dilexi decorem tuum, et locum habitationis gloriæ Domini mei, fabricatoris et possessoris tui!—St. Augustine.

THE SUN.

The solar phenomena are especially wonderful. The unrivalled pre-eminence of that glorious sphere, the dependence of our whole system upon the mysterious processes developed at its surface, the rapid and extensive disturbances of which it is the scene, as well as the daily visibility of the object, all combine to invite research. But the student had better not begin here: more than one astronomer has suffered from that piercing blaze: Galileo probably thus blinded himself wholly, and Herschel I. in part. With due precaution, there is no danger; but the eye and hand had better first acquire experience elsewhere. Much depends on the dark glass of the solar cap which is to be screwed on the eye-piece; red is often used, and *may* be dark enough—it is not so always—but it transmits too much heat; green is cooler, but seldom sufficiently thick. The Germans have employed deep yellow, probably to save the brightest and most central rays of the spectrum. Herschel I. adopted, with great success, a trough containing a filtered mixture of ink and water. Cooper, at Markree Castle,

Ireland, used a 'drum' of alum water and dark spectacles, and could thus endure the whole aperture, $13\frac{3}{10}$ inches, of his great 25-foot achromatic.* With large apertures, a plane surface of unsilvered glass placed diagonally, as originally suggested by Herschel II., so as to reflect only a small fraction of the light and heat, is found of eminent service. Merz, of Munich, has so reduced the light by polarisation at four such surfaces, that a dark glass, the tint of which is of course better dispensed with, becomes unnecessary: and the same end is attained in a very ingenious double-prism eye-piece devised by Prof. Pickering: neither apparatus, however, is free from accidental colour. An eye-piece has been constructed by Andrews with two lenses of complementary tints, burnished in loosely to avoid fracture from expansion, which has succeeded with a small aperture. In screen-glasses combinations of colour are good. Red succeeds perfectly with green. Herschel II. used green and cobalt blue.† If there is to be only one solar cap, deep bluish grey, or neutral tint, will be quite satisfactory; if several, it would be worth while to have different colours, Secchi's observations at Rome seeming to show that the visibility of very delicate details may depend on the tint. In the absence of a proper screen, smoked glass may be used: it is said to intercept heat very perfectly, by Prince, who places it within the eye-piece, close to the 'stop,' or circular opening, which bounds the field; but thus it can have only one degree of depth, and must be taken out to view other

* Dawes thought, that with a focus of 30 inches, 2 inches of aperture were enough for perfect safety.

† The value of complementary, or at any rate dissimilar, tints in protecting the eye was known before the telescope. Fabricius observed a solar eclipse in 1590 'per duplex diversi coloris vitrum;' and Apian speaks of them 50 years earlier.

objects. A strip of glass may be smoked to different densities in different parts, and held between the eye and eye-piece; but it should be protected from rubbing by a similar strip of glass placed over it, and kept from touching by bits of card at the corners, the edges of the two strips being bound round with gummed slips of paper, or tape.* Where expense is not regarded, an optician will provide a delightful graduated screen with two wedges of glass, plain and coloured. In any case we must not begin with too faint a shade, but try the deepest first, and change it if necessary. The thickness of any external screen will contract the field much, unless the eye is brought as close up as possible. A pleasanter view is obtained by placing the screen within the adapter, but from its larger surface it will require to be worked very true.

To bring the Sun into the field, do not attempt to look for it with the finder unless it has a solar cap: point the telescope till the finder shows it centrally on the hand, or on a paper held behind it; or bring it to shine through the eye-piece *before* the dark cap is screwed on.

With these precautions, there is no fear for an ordinary sight; but should the light or heat be still unpleasant, the aperture may be contracted as recommended for defective glasses; † or for a very sensitive eye, or a whole company at once, the image of the Sun may be received direct from the

* Gum-water, or mucilage, should be always made with *cold* water. It is far stronger, and keeps a long time without growing mouldy.

† Schwabe used a contracted aperture and light screen; Herschel I. and Dawes preferred full apertures and deep screens, for sharper definition. A small aperture has, however, one material advantage in preserving the screens from cracking. I have known a double screen demolished in a few seconds: partial fusion also, or blistering, may be produced by a large aperture.

eye-piece, without any screen, on card. Choose a field large enough to take in the whole disc, and alter the focus till the image on the card is *quite* sharp, and at a convenient distance as to size; any spots then visible will be easily and, with due precaution, very fairly seen. And so will specks of dirt in the eye-piece; but these may be detected by moving the tube, as the true spots alone will keep their places in the image. If the eye-piece includes only part of the Sun, do not mistake the edge of the field as shown on the card for the Sun's limb; both are circular, but the latter only will move so long as the telescope is fixed. If a circle of suitable size is drawn on the card, and crossed by lines forming small squares, the image may be adjusted to coincide with it, and the progress of the spots may be marked and recorded day after day. Noble has found that plaster of Paris, smoothed while wet on plate-glass, gives a most beautiful picture; he fixes a disc of it inside the base of a pasteboard cone, blackened inside, 1 foot long, and 6 inches across the large end; the small end being opened so as to fit close on the eye-piece, with a hole in the side of the cone to look at the image. Howlett prefers the projected picture to a direct view. It has at any rate the advantage of avoiding the tinge given by a screen-glass. In either mode of observation, if an achromatic is employed, it is an excellent plan to shade the face in the one case, or the screen in the other, by a large piece of pasteboard with a hole in it, through which the tube passes.

All being arranged, we shall find four points especially worthy of attention: 1, the dark spots; 2, the faculæ; 3, the mottled appearance; 4, the transparent atmosphere.

1. The *Dark Spots*. These are not always visible; the disc is occasionally entirely free from them, but more fre-

quently one or more will be in sight. Unless very small, they generally consist of two perfectly distinct parts—a dark 'umbra,' usually termed the 'nucleus' by the older observers, often very irregular in its outline,* which resembles, as Secchi remarks, the creeping of a very dense luminous material over an extremely rough surface; and a surrounding 'penumbra' (the 'umbra' of former days), a fainter shade with an equally definite, but in general less angular, boundary, usually, according to Schwabe, in proportion to the umbra as 2 to 1, or as 7 to 3. The umbra appears black from contrast, but is not quite so, as is evident when Mercury passes across the Sun. Frequently it is slightly and unequally illuminated, as if partially overspread by a thin haze, which Secchi compares to cirri, or mare's tail clouds, and finds to be the harbinger of its decrease and extinction; sometimes it is intersected by narrow white veins, or bridges; these Huggins has occasionally found of especial brilliancy, and in one of them Secchi detected by the spectroscope a different constitution from that of the photosphere. In Dawes's very ingenious solar eye-piece,† a sliding plate, or wheel, of metal contains a series of holes gradually decreasing in size, each of which may limit the field in turn, while the whole is insulated by ivory, so as to prevent the eye-piece from getting heated; thus most of the luminous part may be shut off, and the spot alone viewed with a very light screen-glass. In this way, he

* A double flexure, like that of the letter S, is not unfrequent. It was noticed by Messier in the great spot of 1759 (the colour of which, he says, was 'brun foncé'); and in modern times by Chacornac and others. Howlett remarks this curve in the grouping of small spots.

† A similar idea had occurred to Professor Wilson, of Glasgow, in the last century, but in a very imperfect and unpractical form.

detected in all large * and many small umbræ, a perfectly black spot, or opening, of much smaller size, which he termed the 'nucleus,' and the presence of which, he believed, might point out an important difference in the origin of the spots. Secchi, who concurs in this discovery, finds that holes in a glazed visiting-card (which may be burnt with a red-hot needle), answer well: the card, however, should be placed a little way from the focus, or the edges of the hole may be charred. A Barlow or even common concave lens interposed before the rays reach the focus will divert a great portion of the heat, and an excellent arrangement will result from a combination of concave lens, card diaphragm, and screen-glass. Howlett and others have occasionally perceived the nuclei without any such assistance, and Buffham has seen them frequently with a $2\frac{9}{10}$ in. object-glass; often multiple; once (1870, June 20) 5 in a single umbra. The feeble illumination of the umbra, Dawes ascribed to the presence of a 'cloudy stratum' beneath the photosphere: this Secchi, with Merz's polarising apparatus, finds tinged with a rosy hue. The most diligent of solar observers, Schwabe of Dessau, has seen an occasional reddish-brown colour in spots, whose immediate contiguity to others of the ordinary greyish-black precluded deception; in one instance, three telescopes, and several bystanders, agreed as to this fact. Capocci, in 1826, perceived a violet haze issuing from each side of the bright central streak of a great double umbra: Secchi, during the eclipse, 1858, March 15, remarked a rose-coloured promontory in a spot visible to the naked eye. Schmidt records many tints, chiefly violet umbræ and yellowish penumbræ, espe-

* He mentions, however, one large and unusually changeable spot, in which he could detect no nucleus (1859). Brayley observes that they had been already figured by Herschel II. at the Cape.

cially as cast on paper; Howlett and others have noticed brown, and Lockyer copper-coloured and violet tints in umbræ.* Birmingham has also seen a red cloud suspended, apparently, across an umbra and nucleus. The penumbra, which in most cases encompasses considerable umbræ, occasionally comprises a group of them, and frequently outlasts them, is made up, according to Schwabe, of a multitude of black dots usually radiating in straight lines from the umbra. Secchi, with greater optical power, finds these radiations to be alternate streaks of the bright light of the photosphere and dark veins converging to the umbra. The penumbra, Herschel II. observes, occasionally shows 'definite spaces of a second depth of shade;' it is generally darkest at the outside;† sometimes it includes brilliant specks, or streaks, even close to the umbra. Schmidt describes one of these insulated specks as the brightest portion at that time visible. They have been frequently seen to disappear in floating over the umbra. Sun-spots are of all shapes and sizes, up to enormous dimensions, the umbra frequently surpassing the earth greatly in magnitude; in 1858 it attained a diameter of nearly 140,000 miles. The penumbra, especially of a group, is often much larger. Herschel II., at the Cape of Good Hope, estimated the area of one to be 3,780,000,000 square miles. Schwabe and Schmidt speak of groups which have extended across more than a quarter of the disc. The length of one, observed by Hevel in 1643, is said to have occupied one-third of it. Spots exceeding 50″, Schwabe finds visible to the naked eye through a fog, or dark glass: he has often re-

* An 'over-corrected' object-glass might possibly cause a violet tinge.

† Such Dawes found to be the case with his cloudy stratum also, but only in opening spots. Buffham and Andrews have seen a nucleus encompassed by a narrow grey ring.

corded such instances, sometimes repeatedly in twelve months; and Dawes states that a year seldom, if ever, passes without them. When thus perceptible they surpass the earth at least three times—if conspicuous, much more. A gregarious tendency is obvious, and the groups are apt, especially in certain seasons, to be nearly parallel with the solar equator. Herschel II. says that, if they converge, it will be towards the preceding side of the disc. They are absent from the poles, and infrequent and of short duration at the equator, which is the hottest part of the globe: on each side of it are two fertile zones, reaching as far as 30° or 35° each way; sometimes they exceed these bounds. Peters (U.S.) saw one in 50° 55′, La Hire in 70° of solar latitude.* The observations of Peters and Carrington tend to unsettle these limits, which may be subject to change: the latter astronomer has ascertained that, previous to the minimum epoch, the spots break out nearer to the equator, and the reverse afterwards. The numbers are said to be greater in the N. than S. hemisphere. Schwabe finds that the W. members of a group disappear first, and fresh ones are apt to form on the other side, on which are the greatest number of minute companions, and on which the spots themselves generally increase, decreasing the opposite way; also that the small points are usually arranged in pairs; and that, near the edge of the Sun, the penumbræ are much brighter on the side next the limb. Herschel II. saw the penumbræ often best defined on the preceding side, and Capocci found that the principal spot of a group leads the way, and that the umbræ are better defined in their increase than diminution. Peters and Carrington observe a remarkable tendency to

* Carrington thinks, however, that this exceptional number may be due to erroneous reduction.

divergence in adjacent umbræ. Groups are frequently elliptical, curvilinear, or bifurcated. The extraordinary mutability of the spots will be obvious; frequently they are in continual change, varying from hour to hour, and even more rapidly. Herschel I. lost a group while merely turning away his eye for a moment: Biela has found spots disappear while he looked at them: Krone has observed them to form within a single minute: Schwabe saw a penumbra increase from 1′3″ to 5′2″ in 24^h. Capocci noticed the temporary reduction of an umbra, four times as large as the earth, to the dimensions of Europe, 'under his eyes:' an unfortunately vague expression, as the Académie des Sciences have remarked, but characteristic of that surprising fluctuation which must strike every observer. Dawes has alluded to the probability that the state of our own atmosphere may be concerned in many of these apparent variations.

The enquiry into their nature is very perplexing, from the absence of terrestrial analogies, the Sun evidently belonging to a wholly different and entirely unknown class of bodies. The theory of Professor Wilson of Glasgow, modified by Herschel I., has been very generally adopted, that the spots are openings in a blazing envelope or 'photosphere,'* through which we see, in the penumbra, a deeper and less brilliant region; at a still greater depth, in the interior of the umbra, a feeble luminosity, marking the 'cloudy stratum' of Dawes (or 'cirri' of Secchi); and below both these the dark body of the Sun, forming the nucleus. This view rests on the perspective appearance of the penumbra, when near the limb,

* Schröter used this very appropriate and now universally-admitted term as far back as 1792.

which usually* is more contracted on the side next the Sun's centre; and the depression has been supposed to be corroborated by several observations of actual notches in the limb.† Herschel I. thought these openings might be caused by invisible elastic vapour, rising from the dark body of the Sun, and expanding in its ascent: such is also the view of Secchi, Chacornac, and Dawes, who refers the brighter edges of the openings to their being 'folded back,' as it were, by the rush from beneath. On two occasions, in 1861, Schwabe found the limb faint and indistinct beyond spots recently entered. Herschel II. inclines to the idea that a transparent atmosphere above the luminous stratum may be subject in its equatorial regions, like that of the earth, to hurricanes, forcing their way downwards to the surface. Circular movements are occasionally traceable: they were noticed by Silberschlag a century ago; and Dawes detected them in two nuclei, one rotating through 100° in 6^d, the other through 70° in 24^h. Secchi has also perceived, besides several cases of rotation, a spiral or whirlwind form in the penumbræ and nuclei of certain spots. Something of the kind has likewise been twice delineated by Birt, and noticed by several other observers;

* De La Rue, Stewart, and Loewy have found, in longitude, 75 cases where the penumbra was equal on both sides, 456 giving the perspective of depression, 74 the reverse; in latitude, 72 cases for, 17 against depression, which they consider sufficiently established.

† An indentation on a globe will disappear in profile, unless its breadth and depth are considerable: hence such observations would be rare; they have been recorded by La Hire, 1703; Cassini, 1719; Herschel I., 1800; Dollond and others, 1846: Lowe, 1849; Newall, 1850, 1859; observers at Kew and Dessau, 1868: but some of these may have been due to inferiority in optical means. If the spots were masses suspended above the photosphere, as Kirchhoff and a few others still maintain, they would, as Howlett well observes, be often seen as notches in the limb.

and, though Spörer thinks it deceptive, it deserves careful attention. The excentricity or lateral deficiency occasionally noticed in the penumbra seems to indicate an oblique direction of disturbance. Secchi has revived Wilson's idea, that the penumbræ may slope inwards: he calculates that their depth is about $\frac{1}{3}$ the semidiameter of the earth, or upwards of 1,300 miles, a depression which the subsequent computations of Faye have extended through a space of from 2,000 to 3,800 miles. Schwabe has remarked considerable differences in depth, and Lockyer thinks the photosphere shallowest at the epoch of greatest spot-frequency: about which time (1870–1871) Holden found the penumbræ very pale, the umbræ light brown, and the nuclei unusually easy of detection. From the nature of the photosphere, we might conjecture that of the spots, were it not equally unknown. Dawes, Huggins, and Schwabe, like Herschel I., infer an irregular distribution of luminous clouds: Arago's polariscope experiments were thought to have shown that the light is that of flame, not of white-hot solid or fluid matter; but the result is questionable. Secchi and Henry have shown that the spots are relatively cool. Herschel II. deduced the partial removal of definite films, floating on a dark or transparent ocean, rather than the melting of mist or mutual dilution of gaseous media, and the analogy of the Aurora Borealis has also been alluded to by him and his father. The idea seems to be becoming prevalent of so complete an absorption of light, in traversing vapour under a certain degree of temperature and pressure, as to produce the appearance of blackness. But we are far, as yet, from any adequate explanation, though our interest in these wonderful processes is increasing, since there is now more than a suspicion that they influence the whole dependent

system. The extraordinary perseverance of Schwabe* has shown that the spots have regular maxima and minima, with a period averaging about 10, or, according to Schmidt and Wolf (from a more extended comparison), 11·2† years, which corresponds so exactly with the period of all magnetic variations, that both, as well as auroræ and electrical earth-currents, are now ascribed to the same unknown power, and the spots are no longer objects of mere curiosity, but indications of a mighty force, one of the prime laws of the universe.‡

The revelations of the spectroscope, which have demon-

* The late lamented President of the Astronomical Society, Mr. Johnson, thus refers to the presentation of their Gold Medal to this observer:—'It was not . . . for any special difficulty attending the research, that your Council has thought fit to confer on M. Schwabe this highest tribute of the Society's applause. What they wish most emphatically to express is their admiration of the indomitable zeal and untiring energy which he has displayed in bringing that research to a successful issue. Twelve years, as I have said, he spent to satisfy himself — six more years to satisfy, and still thirteen more to convince, mankind. For thirty years never has the Sun exhibited his disc above the horizon of Dessau without being confronted by Schwabe's imperturbable telescope, and that appears to have happened on an average about 300 days a-year. So, supposing that he observed but once a-day, he has made 9,000 observations, in the course of which he discovered about 4,700 groups. This is, I believe, an instance of devoted persistence (if the word were not equivocal, I should say, pertinacity) unsurpassed in the annals of astronomy. The energy of one man has revealed a phænomenon that had eluded even the suspicion of astronomers for 200 years!'

† Wolf in 1870 gave $11\frac{1}{9}$y. But see note ‡ below.

‡ Wolf has suspected an additional longer period of 56 years; maximum, 1836. He suggested (1859) that they may result from a reaction of the planets upon the Sun. De La Rue, Stewart, and Loewy believe that they have discovered a connection between their positions and those of Venus and Jupiter, or Mars and Mercury. They find the period not always uniform; but the increase more rapid than the decrease.

strated the existence of 13 or 14 terrestrial elements in the Sun, and given some indications as to its temperature, are among the most surprising of modern astronomical discoveries, and stand on evidence which seems incontrovertible;* but they still leave much to be explained by future investigation; much that we can never reasonably hope to explain. The spectroscope is so seldom found adapted to a 'common telescope' that we need not further advert to it here.

Concurrent authorities have justified our assuming that the spots are openings; yet observations exist, looking another way; and it may be well to insert them from their curiosity, as well as their being seldom referred to. Dr. Long, who published a Treatise on Astronomy in 1764, states that he, 'many years since, while he was viewing the image of the Sun, cast through a telescope upon white paper, saw one roundish spot, by estimation not much less in diameter than our earth, break into two, which immediately receded from one another with a prodigious velocity.' Dr. Wollaston says, 'Once I saw, with a 12-inch reflector, a spot burst to pieces while I was looking at it. I could not expect such an event, and therefore cannot be certain of the exact particulars; but the appearance, as it struck me at the time, was like that of a piece of ice when dashed on a frozen pond, which breaks to pieces and slides on the surface in various directions. I was then a very young astronomer, but I think I may be sure of

* The probability resulting from one or two coincidences in the position of lines would of course be but slight, but it rises rapidly with the multiplication of comparisons. Kirchhoff says, that about 60 lines are common to the vapour of iron and the light of the photosphere, and the consequent chance in favour of its presence is more than 1,000,000,000,000,000,000 to one. Yet this is but one set out of a combination of corresponding lines.

the fact.' It is also stated that Bayley, who sailed twice with Captain Cook, saw a spot split in two.* From such appearances, an observer, unacquainted with the ordinary theory, might easily have inferred the solidity, from the disruption, of the dark object. On chemical grounds, connected (but not as a necessary consequence) with spectrum-analysis, Kirchhoff and Bunsen have deduced a constitution analogous to floating clouds; an opinion adopted by Donati and Spörer. Zöllner ascribes to them a scoriaceous character.

Notwithstanding their changeable nature, the larger spots are possessed of some permanency.† After describing straight lines about June 11 and Dec. 12,‡ but elliptical paths at other times, in consequence of the position of the Sun's equator towards our eye, they go out of sight at the W. limb, and if not dissipated, return at the E. edge after about $13\frac{2}{3}^{d}$ to run the same course. Some have thus persisted through many revolutions. In 1779, a large spot continued visible for 6 months, and in 1840 and 1841, Schwabe observed 18 returns (though not consecutive) of the same group: the most permanent, he says, are usually round, of moderate size, and not sharply defined. Carrington thinks there can be no question of their occasional re-appearance in the same places; and this reduces within certain limits their proper

* Some strange separations and oscillations of umbræ, recorded at Lawson's observatory in 1849, were probably due to the unsteadiness of our atmosphere; and such may have been the case with the luminous bridge which Robinson at Armagh saw shot across some thousands of miles of umbra in a few minutes.

† Howlett has also found some of the smaller and more isolated ones very persistent.

‡ So Herschel II., Outlines of Astronomy, § 390. But in the next paragraph they stand as July 12 and Dec. 11.

motion, which is now an established fact. Fritsch stated that he saw one stand nearly still for three days; and Lowe, that he even witnessed retrogradation; but these assertions involve a suspicion of mistake. Schröter and others have ascribed to them a more moderate locomotion. This was micrometrically established in a lateral direction by Challis in 1857; and Carrington has subsequently made known his very interesting discovery, that there appear to be currents in the photosphere, drifting the equatorial spots forward, in comparison with those nearer to the poles, with deviations in latitude of smaller amount; the neutral line, as to both these drifts, lying in about 15° of latitude.* With these shifting landmarks, it is not surprising that the Sun's period of rotation is still doubtful. Laugier's value, $25^d\ 8^h\ 10^m$, was formerly adopted, but Carrington has given $24^d\ 23^h\ 18^m\ 23^s$, Spörer $24^d\ 14^h\ 59^m$. Perhaps, as Carrington suggests, the interior mass may revolve with greater speed. Relative displacement in groups would be an interesting study, requiring neither micrometer nor clock, only careful drawing. The application of photography to solar delineation, as at Kew and Ely, is not likely to be within the reach of our readers: it is, however, too important to be passed over in silence. Howlett and several others have found that spots near the limb require a different focus from those in the centre; arising, no doubt, as Dawes says, from the effect on the retina of very different degrees of brightness.

2. The *Faculæ*, or bright streaks. Less obvious than the dark spots, and requiring more power, these are not difficult objects; to be looked for in the spot-bearing regions, but

* Peters ascribes to all the spots a *set* towards the equator; Laugier, from it.

only near the limbs.* They are irregular, curved, and branching, considerably more luminous than their vicinity, but not, according to Secchi, than the centre of the Sun. They are proved to be what they appear, ridges in the photosphere, by an observation of Dawes, who once saw a facula projecting above the limb as it turned across it into the other hemisphere, and at another time the luminous border of a large spot which had just entered, forming an irregular low ridge upon the limb: Secchi also has seen a similar appearance. We seldom, however, find them visible close to the limb, or far from it, as they are changed in the centre into bright tufts and specks; an effect, as Secchi has pointed out, of perspective, if their height much exceeds their breadth; or of the elevation of their crests above an absorbent atmosphere. Howlett sees them beautifully projected on a screen, and thus detects them in the centre of the disc. They are nearly as variable as the spots, and are probably connected with them, surrounding them usually near the limb, and sometimes as they cross the centre, attending their development, and succeeding their dissolution; as though they were temporary accumulations of the displaced matter of the photosphere. Secchi compares them to immense waves raised by the outburst of the spots, of which they are commonly the harbingers. Schwabe thinks them rather more obvious when spots are few,† and suspects that one at least, consisting of 5 to 7 connected ovals, and enclosing occasionally a great group of spots, may be a permanent or recurring feature.

* They were observed by Carrington and Noble nearer the centre than usual in 1870, a maximum spot-period.

† He has since adopted an opposite opinion.—*Monthly Notices*, xxvii. 286.

The authors of 'Solar Physics' consider them (and probably the whole photosphere) as consisting of solid or liquid bodies suspended or slowly sinking in a gaseous medium. They find that on an average they follow the accompanying spots, and infer that they have probably been uplifted out of them, and have fallen behind from being thrown up into a more swiftly rotating region.

3. The *Mottled Surface.* An object-glass of only 2 inches will exhibit a curdled or marbled appearance over the whole disc, caused by the intermixture of spaces of different brightness. The earliest mention I have noticed of this mottling is during the solar eclipse, 1748, July 14 (O. S.), when it was clearly described by Mr. J. Short (the eminent optician?), to whom it was quite new: since that time it has been a familiar object; and it must have been this coarser mottling which Schwabe described in 1831, as shewing itself strongest in the spotted zones, like two freckled girdles round the Sun. Should this marbled appearance not be at once detected, a slight shaking of the image by tapping the telescope may render it perceptible. Increase of magnifying power, however, brings out a far more delicate mottling overspreading the coarser irregularity, and occasioned by the juxtaposition of minute patches of greater brightness on a greyer ground. This was first observed by Herschel I., and described in two very valuable but not perhaps sufficiently known papers on the Sun (*Phil. Trans.* 1795, 1801), in the former of which the whole solar surface is said to have 'the appearance of a mixture of small points of an unequal light,' and in the latter is described as 'studded with nodules,' which are also referred to a stratum of self-luminous clouds of unequal thickness, of which the higher and lower regions tend respectively to form

faculæ and penumbræ. It has recently been interpreted by Nasmyth (1861) as the interlacing of a multitude of lenticular masses resembling willow leaves in form, the length of each being ten times its breadth. Considerable discussion has arisen as to the point; but the supporters of this idea are few, and the prevalent opinion is that of Dawes, who had been familiar with the phænomenon since 1830; and found from very careful examination of the photosphere, that it was composed of minute 'granules,' or luminous clouds, irregular in form and size, and separated by less brilliant interstices; thus agreeing precisely with the view given in 1792 by Herschel I. The less luminous interstices are frequently stippled with dusky or nearly black points, seldom circular, and often arranged in rows. In the faculæ and round the penumbræ, where the photosphere appears to be heaped up or rolled together, these interstices usually disappear, and the compressed and elongated granules, like very slender faculæ, extend over the penumbra, and often project, like irregular thatch, on to the outer border of the umbra; or, many being joined together, cross the umbra and nucleus as luminous bridges. The grey interstices were thought by Herschel I. to be portions of a lower stratum; but, as he remarked, the depression must be very slight, since they are visible in extreme foreshortening towards the limb. This view is adopted by many of our best observers, including Fletcher, Lockyer, Huggins, and Knott; and is supported by O. Struve, Secchi, and Le Verrier. Huggins adds his impression, that the general surface on which the granules are strewed is itself 'corrugated into irregular ridges and vales,' not unlike a stormy sea; and coincides with the idea of Herschel II. as to 'a luminous medium intermixed but

not confounded with a transparent and non-luminous atmosphere.'

4. The *Transparent Atmosphere.* That this exists, and is of far greater proportionate extent than planetary atmospheres, is demonstrated in total eclipses by the red prominences which then surprise the spectators, and which may, as Jansen and Lockyer have discovered, be detected at any time by the spectroscope; but the presence, and the comparative shallowness, of an absorbent envelope forming its interior stratum is at once evident from the faintness of the limb compared with the centre of the disc. This was early remarked at Rome by Luca Valerio, called by Galileo the Archimedes of his time: it was denied by the inventor of the telescope, but may be easily perceived when the image is cast on paper, and its effect is evident in the Kew, and especially the Rutherfurd photographs.* By means of a doubly refracting prism, Secchi has found the limb not more luminous than the penumbræ of spots in the middle of the Sun, that is, deprived of about half the light; † and his previous discovery of a similar decrease of heat confirms the existence of such an absorbent stratum. Hence also may result the inferior distinctness of the solar limb as compared with that of the Moon in eclipses, a fact remarked by Airy, and exhibited by photography; and Secchi has observed that the occasional bad definition of the spots

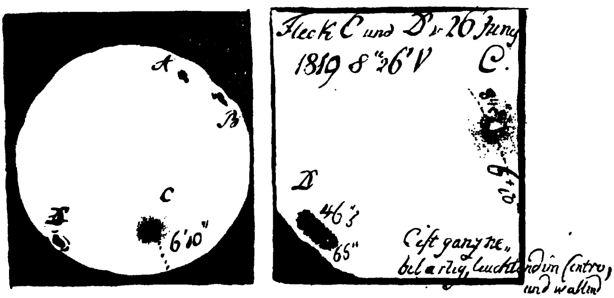
* Arago's polariscope failed to exhibit this difference; it has been shewn by the latter observations of Schwabe, that it does not invariably exist, and that when it is not perceptible, there is also an absence of faculæ, 'scars,' and pores.

† He has subsequently reduced this to $\frac{1}{3}$ or $\frac{1}{4}$, and finds the limb of a very decided smoky red tint. Elger has seen a portion of the disc near the limb intensely brown where large spots have disappeared.

may be due to the solar atmosphere instead of our own. Some measures of his, and observations by Spörer, seem to indicate a refractive power in this atmosphere, producing an apparent displacement of the spots towards the limb.

Something must be said of the Sun as a background for the exhibition of intervening bodies. Partial solar eclipses seldom gain much interest in the use of the telescope, excepting from the occasional projection of mountains on the Moon's limb. The total eclipse is so wonderful and so fugitive as to require special preparation, and is too rare in England to require notice here. The transits of Mercury will be found under the head of that planet: those of Venus are too uncommon and distant to be admitted in our limited space; the next visible in England not occurring till 1882, its successor not till 2004. Comets, from the endless diversity of their paths, must occasionally pass over the Sun; and the opportunity of such a background would be most valuable for acquiring more information as to their nature. This actually took place, 1819, June 26; but it was not known till afterwards, when a controversy arose as to whether the stranger had been visible. Pastorff maintained that he had that day seen on the Sun a round dark nebulous spot with a bright point in the centre: Olbers and Schumacher thought there was no ground for supposing it to have been the comet; but, most fortunately, the original sketch of Pastorff, which is still in existence, and of which, through Sir J. Herschel's kindness, I have been enabled to give a copy (omitting only an attempt to shew the mottled aspect), satisfactorily establishes the accuracy of that unique and most curious observation.

This astronomer has left three volumes of drawings of the solar spots, commencing just in time for our present purpose



COMET OF 1819

IN TRANSIT OVER THE SUN.

as that in question is only the third from the beginning. According to his frequent practice, an enlarged view of the most remarkable spots is set beside one representing, in somewhat careless proportion, the whole disc. The singular contrast between the transparent nucleus and dusky coma is in striking harmony with the spectroscopic discovery of Huggins: this feature, missed or obliterated in the general sketch, is especially delineated in the detailed one; and the whole aspect carefully described in the German annotation, 'C is quite hazy, luminous in the centre, and *boiling*' (atmospherically unsteady). On the following day is the confirmatory remark that D (going off the limb) and C had vanished. The care with which the strange spot was observed is evident from the micrometrical measure of its extent. In 1826, Gambart found that a comet which he had discovered would be on the solar disc a little after its rising on November 18, and gave immediate warning to the astronomers of Europe; but the weather caused almost universal disappointment; only Gambart and Flaugergues had a view of the Sun, and neither of them could perceive a trace of the comet. If anything unusual should ever be noticed on the disc, it should be carefully watched; and should its rate of progress shew that it is not an ordinary spot, its appearance ought to be most critically examined with various powers and screen-glasses, and information sent instantly to the principal observatories within reach, that if a comet, it may be re-discovered as soon as possible.

But there is another reason for attention to anything of unwonted aspect on the Sun: it appears that opaque bodies, of unknown but most mysterious character, traverse it from time to time. The following details comprise a summary of the principal recorded instances; and the room allotted to

them will, it is believed, be justified by the singularity of the subject:—

1761, June 6. Round black spot=¼ ♀, traversing Sun during transit of ♀. Scheuten (probably the least reliable case).

1762, end of Feb. Round black spot, not visible next day: 'Might this have been a new planet?' Staudacher.

1762, Nov. 19, after sunrise. Large round black spot; left disc after traversing chord of 70°. Lichtenberg.

1764, beginning of May. Large round black spot, which seemed to have independent motion. Hoffmann.

1784. Round spot, not found some hours afterwards. D'Angos, at Tarbes.

1798, Jan. 18. Black, well-defined, somewhat elliptical spot, about half way from centre to limb, in motion, and watched to its egress about 20^m afterwards. D'Angos. (The Chevalier's reputation for accuracy does not stand very high. Smyth tells us that, in commemoration of some strange mistakes, Baron de Zach 'was induced to term any egregious astronomical blunders—*Angosiades*.' Still there is something very circumstantially credible in the story as he has told it.)

1800, Mar. 29. Small black spot, almost without penumbra, increasing its distance from limb 18¼′ in 6^h. Fritsch at Quedlinburg; who was fond, however, of ascribing proper motions to solar spots.

1802, Feb. 7. Spot shewing rapid and anomalous motion. Fritsch.

1802, Oct. 10. Spot moving 2′ in 3^m, and not found after cloudy interval of 4^h. Fritsch.

The next instance is so well attested that it seems a pity to curtail it: it is thus given by Mr. Capel Lofft, of Ipswich, in

a letter to the Monthly Magazine, dated 1818, January 10. 'I saw it about 11 A.M.' (on January 6), 'with my own reflector, with a power of about 80; with an excellent Cassegrain reflector made by Crickmore of this town, with about 260; and with a reflector of Mr. Acton's, with about 170. It appeared, when I first saw it, somewhat about one-third from the eastern limb, subelliptic, small, uniformly opaque. About $2\frac{1}{2}$ hours, P.M., it appeared to Mr. Acton considerably advanced, and a little west of the Sun's centre; and I think it appeared then 6 or 8 seconds in diameter. I had been able to see no spot on the 4th, nor again on the 8th, and even on the 6th Mr. Crickmore could not see it a little before sunset, though the telescope already mentioned gave him every advantage. Its apparent path while visible seemed to make a small angle with the Sun's equator. Its state of motion seemed inconsistent with that of the solar rotation, and both in figure, density, and regularity of path, it seemed utterly unlike floating scoria. In short, its progress over the Sun's disc seems to have exceeded that of Venus in transit. There are two instances, if not three, of comets seen in transit, and this phænomenon seems to have been one. I wish it may have been seen elsewhere.'

1819, Oct. 9. Well-defined round spot, about= ☿, not to be found again in the evening. Stark, canon of Augsburg, a regular meteorological observer.

1820, Feb. 12, $10\frac{3}{4}^{h}$. Spot unlike all the rest; well-defined, circular, orange-red, and surrounded by an atmosphere; crossed Sun in nearly 5^{h}. Steinheibel, a practised solar observer. Seen also by Stark at noon, as a singular, well-defined, circular, orange-gold spot, nearly twice the size of ☿, with circular atmosphere, which was not visible in the evening. (One of the most remarkable of these strange accounts,

and at the same time one of the best attested; there seeming no reason to doubt that the two observations, though so similarly worded, were entirely distinct and independent).

1833. Pastorff saw a small round spot so frequently on the Sun, that he suspected its planetary nature; but it does not appear that he marked its rate of progress, and it was unnoticed by others.*

1847, 1st half of July. Spot like ☿ in transit. Scott; Wray (London).

1857, Sep. 12, 1^h P.M. Roundish spot about $5'$ from N. limb, not much smaller than ☿. 13, cloudy. 14, that spot had disappeared, others remaining visible. Ohrt.

1858, Aug. 1. Circular opaque body moving from E. to W. watched from 4^h to 5^h 30^m. Wilson (Manchester).

1859, Mar. 26. Small dark body, about $3''$, crossing part of disc; egress 5^h 47^m. Lescarbault. (The celebrated pseudo-Vulcan. Liais, in Brazil, saw nothing at the same hour.)

1862, Mar. 20, A.M. Sharply defined round black spot of about $7''$; watched in progress for 20^m. Lummis (Manchester). Seen also by a friend.

1864, Feb. 12, 8^h 20^m. Spot of $8''$ crossed disc at a rate between those of ☿ and ♀. Beswick, N. York (doubtful).

1865, May 8, 9^h 28^m. Round black point moving across disc: oval just at exit, 48^m afterwards. Coumbary (Constantinople).

Whatever allowance may be made for mistaken impressions

* Wartmann has stated that, in 1834, 36, and 37, Pastorff saw little bodies form over the disc in comparatively short spaces of time. Pastorff's own records end in 1833. *Monthly Notices*, xx. 67. (For *form* read *pass*?)

in some of these cases, enough remains to prove the reality of these strange occurrences. With so much opacity, it is singular that they should never have been seen by reflected light (except, as has been suggested, in the possible case of the supposed satellite of Venus); and that all of them should be interior to the orbit of the Earth.*

It may never be granted to our readers to witness such a wonderful outburst of light in front of the Sun as was observed by Carrington and Hodgson, 1859, Sep. 1: and repeated, according to Brodie, on a minor scale, 1864, Oct. 1. But should any of them be so fortunate, the propriety need scarcely be mentioned of the greatest care in the record, and readiness in the publication, of such an event.

MERCURY.

THIS planet, though at times readily visible to the naked eye, is but seldom seen from its nearness to the Sun, and often lies too near the horizon for the telescope. A well-adjusted equatorial stand will find it by day, but its small diameter of less than 3,000 miles subtends at a mean not more than 6″ or 7″;

* An examination of the original memoir shews that an observation by Messier, 1777, June 17, which has been thought of a similar nature, points rather to the intervention of drops of rain or hail-stones. The dark bodies seen crossing the Sun by Capocci and others at Naples, 1845, May 11, 12, 13, were evidently, as Dawes has pointed out, light bodies, such as seeds, floating in our own atmosphere. On three occasions, 1847, Oct. 11; 1849, Oct. 14; 1850, Feb. 28, Schmidt witnessed the transit of black bodies, the two latter of 15″ and 30″, and from W. to E., which he believed not to be birds or insects. But the rapidity of their movement transfers them to another class. They may have been meteors.

and ordinary observers will not see much, where professed astronomers have usually found little. But as these pages may possibly fall into the hands of some, whose advantages or enterprise may lead them to attack a neglected object, the following points may be specified.

1. The *Phases*. These will be easily seen, and are only remarkable because the breadth of the enlightened part has been sometimes found less than it should have been from calculation. Schröter noticed this: Beer and Mädler confirm it, but their explanation of a dense atmosphere enfeebling the terminator, or boundary of light and darkness, is inadequate, as their observation was before sunrise, when even the dullest part of the disc would be very luminous. See this again in Venus.

2. The *Mountains*. At the close of the last and beginning of this century, Schröter, of Lilienthal in Hanover, a most diligent observer, and his assistant Harding, obtained what they deemed sufficient evidence of a mountainous surface in the occasional blunting of the S. horn,* some minute projections on its outer edge, and an irregular curve of the terminator; they gave the inferred elevations a height of nearly 11 miles perpendicular.

3. The *Atmosphere*. The decrease of light towards the terminator, and the occasional presence of dark streaks and spots, indicated to the same astronomers a vaporous envelope, where they thought they even saw traces of the action of winds. From a combination of various appearances they deduced a rotation in $24^h\ 0^m\ 53^s$ on an axis inclined about 70° to the ecliptic of Mercury. A spot with faint lines diverging from it, NE. and S. was seen by Prince a little S. of the centre, in unusually clear air, 1867, June 11.* Birmingham also was pretty

* Noble also has suspected this (1864).

certain that there was a large white spot near E. limb, 1870, March 13. In De La Rue's magnificent Newtonian, 10 f. focus and 13 in. aperture, constructed by himself, the planet has a rosy tinge. Secchi has remarked that the disc is always very ill-terminated, and very faint at the edges.

Transits of Mercury are comparatively frequent; they will be visible in Europe in 1878 and 1894. The planet breaks in upon the Sun as a dark notch, sometimes preceded, it is said, by a penumbral shade; but the earliest impression will be missed, unless the exact point of the Sun's limb is known, and kept central in the field. As it advances, the part of Mercury not yet entered may be rendered visible by being projected upon the 'corona,' which is so conspicuous in total solar eclipses, and has been known to relieve dark bodies in front of it, such as an inferior planet, or even a portion of the Moon. On finally entering the Sun, or beginning to leave it, the planet has been seen lengthened towards the limb from irradiation: fully on the disc, where Mercury appears intensely black, some astronomers have given it a slight dusky border, others a narrow luminous ring: both, probably, deceptions from the violent contrast and the fatigue of the eye, especially as others have remarked nothing of the kind. A similar explanation may be applied to a whitish or grey spot on the dark planet, seen by Wurzelbauer, 1697, Schröter, Harding, and Kohler, 1799; Fritsch and others, 1802; Moll and his assistants, 1832 (when Harding *clearly* distinguished *two* spots, and Gruithuisen suspected one); and recognised in England and America, 1848, and by Huggins and Elger, 1868: when Browning perceived *two* spots again. No terrestrial analogy will explain a luminosity thus visible close to the splendour of the Sun; and it seems natural to refer it to

the exhausted state of the retina: an artificial disc, however, subsequently tried by Huggins, shewed nothing of the kind. And everything that is seen, however improbable, should always be recorded: an opposite procedure would have effectually precluded many an important discovery. We may remark that Schröter and Harding ascribed to these spots a motion corresponding with the rotation which they subsequently inferred from other indications.*

VENUS.

Fairest of stars, last in the train of night,
If better thou belong not to the dawn,
Sure pledge of day, that crown'st the smiling morn
With thy bright circlet, praise HIM in thy sphere.

MILTON.

THE most beautiful of all the heavenly bodies to the unaided eye is often a source of disappointment in the telescope. For the most part it resists all questioning beyond that of Galileo, to whom its phases revealed the confirmation of the Copernican theory; an important discovery, which he involved for a season in the following ingenious Latin transposition:

Hæc immatura à me jam frustra leguntur, o. y.

the letters in their original order forming the words

Cynthiæ figuras æmulatur mater amorum.

Observers in general will subscribe to the experience of Herschel II., who says it is the most difficult of all the planets

* A similar phænomenon was observed on Venus in the transit of 1761 (Append. ad Ephem. Astron. 1766, 62).

to define with telescopes. 'The intense lustre of its illuminated part dazzles the sight, and exaggerates every imperfection of the telescope : yet we see clearly that its surface is not mottled over with permanent spots like the Moon ; we notice in it neither mountains nor shadows, but a uniform brightness, in which sometimes we may indeed fancy, or perhaps more than fancy, brighter or obscurer portions, but can seldom or never rest fully satisfied of the fact ;' and he infers, like his father, and Huygens long before, that 'we do not see, as in the Moon, the real surface of these planets' (Venus and Mercury) 'but only their atmospheres, much loaded with clouds, and which may serve to mitigate the otherwise intense glare of their sunshine.'* Notwithstanding, however, the authority of this opinion, perseverance has of late years rendered it at least very doubtful: and moderate-sized instruments have proved occasionally of service. Further observations of this planet are much needed, and would probably be rewarded by interesting results. The following are the chief points to be noticed :—

1. The *Phases*. These are easily seen, and very beautiful, excepting the dull gibbous form in the *superior* or further part of the orbit, where the disc is also small; near the greatest elongation from the Sun towards the E. when she is an evening, or W. when a morning star, Venus puts on a beautiful shape—that of the moon in quadrature; between these points in the *inferior* or nearer part of the orbit, she is a most elegant

* Chacornac is of the same opinion, from the absence of polarization in the light of Venus. His apparatus shews her brightness to be 10 times greater than that of the most luminous parts of the Moon. The reduction of her light to $\frac{1}{2000}$ perceptibly diminished the image from removal of irradiation (?). Jupiter the same.

crescent, larger, sharper, and thinner in proportion as she is nearer really to the Earth and apparently to the Sun. This crescent has been seen even with the naked eye in the sky of Chile,* and with a dark glass in Persia, and a very small telescope will shew it. When quite slender it should not be looked for after sunset or before sunrise, as it lies too low in the vapour; but an equatorial stand will find it in the middle of the day—an exquisite object; and thus, or in a transit instrument, it has been many times traced as a mere curved thread extremely near the Sun.† Ordinary observers may succeed in seeing it a very delicate crescent soon after it has passed its inferior conjunction, by watching for its earliest appearance

'Under the opening eyelids of the morn,'

setting the finder, or the telescope with the lowest power, upon it, and following it at intervals sufficient to keep it in the field, till it has cleared the vapours of the horizon; in this way it may be readily viewed for hours. In fact, the planet is best seen for many purposes in the day-time; its light, unpleasantly dazzling in a dark sky, so as to bear a screen-glass, is subdued by day to a beautiful pearly lustre. Nor is it very difficult to find. For some time about its greatest brightness, at 40° from the Sun in the inferior part of the orbit, it not merely casts a shade by night, but is visible to the naked eye at noon-day, provided its position is pretty well known. A little careful steady gazing will then bring it out as an intense white point, and, if the air is good, it will be a charming telescopic object.

* Theodore Parker saw it in America when 12 years old, and ignorant of its existence, and when no one else could perceive it.

† Dawes considers that, with due precaution, Venus might be seen in her upper conjunction within 1′ of the Sun's limb.

At other seasons, a little hand telescope with a large field will shew it much sooner in the evening or later in the morning than might have been expected. Like that of Mercury, the phasis often disagrees with calculation; at its greatest elongations it ought to be exactly 'dichotomized' as a half moon; but in August, 1793, Schröter found the terminator slightly concave in that position, and not straight till eight days afterwards; and Beer and Mädler fully confirmed this by many observations in 1836, proving that the apparent 'half-moon' takes place six days earlier or later than the computed, according to the direction of the planet's motion. They found also that there is a similar defect in the breadth of the crescent-phasis. Neither their explanation of this, through the shadows of mountains, nor Schröter's, through the fading of light towards the terminator, is satisfactory as far as night observations are concerned. In 1839 De-Vico and his assistants at Rome found a similar discrepancy of about three days. This curious phænomenon is so easily seen, that I perceived it with an inferior fluid achromatic, on Barlow's plan, 1833, March 6, before I knew that it had been noticed by others.

2. The *Mountainous Surface.* La Hire, in 1700, with an old 16 f. refractor, power 90, professed to see irregularities in the crescent when very narrow; and Briga not only described an indented terminator, but unjustifiably altered Cassini's figures accordingly. But Schröter's observations at the end of the last century are far more trustworthy. With several fine reflectors and a very good achromatic, he and others found the boundary sometimes slightly jagged, sometimes irregular in curvature, so as to vary the relative thickness of the horns; and these would occasionally pass through such changes as to shew a rotation in $23^h\ 21^m\ 8^s$. At the quadrature, the

N. cusp would frequently project, while the S. was blunted, with sometimes a minute point cut off from it by a narrow black line, the shadow apparently of a lofty ridge; some of these mountains Schröter supposed to be 27 or 28 miles high, but of course with great uncertainty. Herschel I. attacked these discoveries in the Philosophical Transactions for 1793, in what Arago justly terms 'une critique fort vive, et, en apparence du moins, quelque peu passionnée.' Schröter calmly and satisfactorily vindicated himself through the same medium in 1795; and Beer and Mädler, in 1833 and 1836, have fully established his accuracy as to an irregularly curved terminator, causing great and rapid changes in the shape of the cusps. They also saw an occasional bending off of the S. horn, corresponding with Schröter's flattening of the limb in that direction.* Fritsch, in 1799 and 1801, witnessed several of these appearances with a little achromatic of 2½ f. focus. Flaugergues and Valz noticed an irregular terminator, but deny its changes. Breen, with the great Northumberland telescope at Cambridge, of 19½ f. focus, and 11½ in. aperture, has often seen the unequal curve of the terminator, and the blunted S. horn. But the most curious observations are those made by De-Vico and his assistants at Rome, in April and May, 1841. An achromatic by Cauchoix, 6¼ in. aperture, with powers sometimes up to 1,128, enabled them to trace the approach towards the terminator, night after night, of a valley surrounded by mountains like a lunar crater, 4″5 in diameter. The crescent was narrow, and near the N. horn

* It is a pity that the figures in their 'Beiträge' are so bad. Schröter's, though not good, are more intelligible. The Roman observers also have noticed this strange temporary flattening of the circular limb near the S. horn, and consider it a profile view of one of the large grey spots, which, if so, must be deeply depressed.

they first saw an oblong black spot, which afterwards was bordered with stronger light, in the sequel encroached with half its ring upon the dark side, and ultimately formed a black notch between two bright projections, giving the appearance of a triply-pointed horn; a longer black streak was seen near the other cusp at the same time. Secchi, in 1857, with the $9\frac{6}{10}$ in. Merz achromatic, when the crescent was only 0″4 broad, observed it to be still further contracted in one part.

3. The *Spots*. These have occasioned much controversy, from their indistinctness, which is such that the Virgilian 'aut videt, aut vidisse putat' is often the observer's conclusion. There have been, however, many exceptions. In 1666 and 1667 Domenico Cassini, at Bologna, repeatedly saw one bright and several dusky spots, the former giving a rotation in $23^h\ 21^m$; subsequently, in the air of France, he never could recover them. In 1726 and 1727 Bianchini, at Rome, observed spots many times with a 66 f. refractor, aperture a little more than $2\frac{1}{2}$ in., power 112, like the 'seas' in the moon to the naked eye, though less distinct, and not till after sunset, from want of light in his glass. His figures shew them surrounding the equator of Venus, forming, as it were, three oceans, one tolerably circular, the others much lengthened, and each of the latter subdivided into three portions connected by narrow straits; besides two spots, one occupying the S. polar region, the other forming a horse-shoe round the N. pole. He did his work well, but for want of *sky-room*, did not perceive their rapid motion, and gave a wrong rotation of $24^d\ 8^h$. Schröter and Herschel I., half a century later, with much finer instruments, but in less pellucid skies, could only make out through many years a few faint markings, with suspicions of motion: at last, 1801, Aug. 29, Schröter detected a dim ob-

lique dusky streak, like one on Mercury, giving a rotation in about 24^h. Several other astronomers had occasional glimpses of darker shadowings; Gruithuisen perceived minute brilliant round specks, and Schumacher a dusky spot in the twilight, which in half an hour was lost in increasing glare; others, visible with a small telescope, he found effaced in a larger one —a caution for future observers. Much more effective results were obtained at Rome, 1839–1841, by De-Vico, who had been instigated by Schumacher to verify Bianchini's assertions in the same atmosphere. He used the Cauchoix achromatic chiefly by day, since in a dark sky the glare overpowered the spots so much as to render the micrometer useless, and account for Bianchini's erroneous rotation: the drawings of the latter were however found, save in the omission of one small spot, remarkably exact. Of six observers, the most successful in seeing these faint clouds were those who had most difficulty in catching very minute companions of large stars; * but all agreed in the figures, and witnessed a progression, giving a rotation in $23^h\ 21^m\ 22^s$ on an axis greatly inclined, though less so than Bianchini had supposed. They have given no less than 145 delineations; many of these are very coarsely executed, but as they are little known in England, copies of a

* De-Vico assigns no reason, but it seems obvious enough, and worthy of notice. A very sensitive eye, which would detect the spots more readily, would be more easily overpowered by the light of a brilliant star, so as to miss a very minute one in its neighbourhood. There is abundant industry in these Roman observations: Palomba, the assistant, made 11,800 measures in 1839, of which 10,000 were employed in determining the rotation. But De-Vico's style wants explicitness, and there are strange traces of inexperience or inattention in the Jesuit College, rendering the memoirs of that date less satisfactory than those of the succeeding Director, Secchi, a man of very different mould.

few of the more characteristic are given here. Of late these spots have been frequently recognised by many of our English observers, De La Rue, Huggins, Worthington with a 13 in. mirror, Seabroke with the 8¼ in. achromatic once belonging to

Dawes, and others, and described as bright patches and specks, and cloudy and crater-like markings of different forms and sizes; according to Ormesher, much like the spots of Mars. Could we but see these features more readily, what an interesting object would this lovely planet become, especially as in point of size it is the only companion to the Earth in the whole system! And the possessors of even common telescopes need not despair, though their chances may not be great: at Rome the spots have been seen even with a little telescope of 2 in. aperture, and the following recital shews that the chief difficulty lies in our own atmosphere; it is so curious that it must be given entire from the Philosophical Transactions: 'January 23rd, 1749–50, there was a splendid Aurora Borealis. About 6^h P.M., the Rev. Dr. Miles, at Tooting, had been viewing Jupiter and Venus, and shewing them to some friends, with one of Short's reflectors, greatest power 200, when a small red cloud of the Aurora appeared, rising up from the SW. (as one of a deeper red had done before), which proceeded in a line with the planets, and soon surrounded both. Venus appearing still in full lustre, he viewed her again with

the telescope, without altering the focus, and saw her much more distinctly than ever he had done upon any occasion. All his friends were of the same opinion as to the sight they had of her on that occasion. They all saw her spots plain, resembling those in the Moon, which he had never seen before, and this while the cloud seemed to surround it as much as ever; but whether the vapour might be rarer nearer the planet, no judgment could be made, because of her too powerful light.'

4. The *Atmosphere*. The bright border noticed by some observers as attending the circular limb may be a deception; but there is very sufficient proof of the existence of a vaporous envelope. Schröter's dusky belt, already mentioned, indicates it.* He has ascribed to it the great decrease of light towards the terminator and cusps; and he and Herschel I. agreed as to the extension of the horns beyond a semicircle, which may be due in part to the penumbra, or additional daylight caused by the Sun's not being a point but a great disc, but more to refraction through an atmosphere. Schröter also perceived a faint gleam along the limb beyond the horns, a true twilight produced by an atmosphere which must be somewhat denser than our own. In May, 1849, Mädler found the horns projecting to 200° and even 240°, shewing a refraction about $\frac{1}{6}$ stronger than ours; and hence Cassini in 1692, and Drew in 1854, found the crescent too broad near the conjunction. Secchi, in 1857, saw in that position the cusps much prolonged, and the twilight extending $19\frac{1}{2}°$, even through our strongly

* Similar ones have been recently detected by Buffham, and a long, narrow line, possibly atmospherical, by De La Rue and Lord Rosse in the great Melbourne reflector.

illuminated atmosphere; and in 1866 Lyman found the delicate ring complete.

5. The *Phosphorescence of the Dark Side.* This truly unaccountable appearance * is remarkably well attested. It is noticed as far back as 1715, in the 'Astro-Theology' of Derham, who says that 'this sphæricity, or rotundity, is manifest in our Moon, yea and in Venus too, in whose greatest Falcations the dark part of their Globes may be perceived, exhibiting themselves under the appearance of a dull, and rusty colour.' 1720, June 7, Kirch, junior, believed that he saw it, the crescent being then extremely narrow. Herschel I. perceived traces of it. In 1806 it displayed itself beautifully to Harding three times, and to Schröter once, within five weeks. Pastorff also witnessed two of these especial appearances. Guthrie and others noticed it a few years ago, with small reflectors, in Scotland; Purchas, at Ross, in England; De-Vico and Palomba, many times, in Italy. Berry at Liverpool saw it in 1862 with no previous recollection of its visibility: it was remarked in that year, and especially in 1863, by many observers in England, and by one in 1865, as well as by four at Leipzig with the 8½ in. achromatic. Strange to say, it has been seen in the day-time: by Andreas Mayer, 1759, Oct. 20, through merely a transit instrument, 44^m after noon: 'etsi pars lucida Veneris tenuis admodum erat, nihilominus integer discus apparuit, instar lunæ crescentis, quæ acceptum a terrâ lumen reflectit:' and Winnecke records

* Arago's 'negative visibility' is a very perplexing attempt at solution. The faint illumination which renders some of our terrestrial nights lighter than others, remarked by Schröter, Arago, and, I think, by myself, scarcely affords an analogy. Humboldt gives a striking instance, Cosmos I., 131 (Bohn).

a similar observation, though very faint, 1871, Sept. 25, a little before noon. Von Hahn also says he saw it repeatedly, by day as well as night, and with several instruments; he was, however, an inferior observer. The dark side is frequently too small in proportion, like that of the crescent Moon to the naked eye; and from the same cause,—the irradiation of the luminous part; it is sometimes described as grey, sometimes reddish. It would be well worth looking for when the crescent is narrow, but Venus should have high N. latitude to clear the vapours of the horizon.

6. The *Satellite*. This is an astronomical enigma. It is not easy to set aside the evidence of its occasional appearance, but it is more difficult to understand why, if it exists, it is so seldom visible, for the diameter ascribed to it is about $\frac{1}{4}$ that of Venus. Cassini saw it in 1672 and 1686; Short in 1740;* Mayer in 1759; Montaigne in 1761; Rödkier, Horrebow, and three others, at Copenhagen, and Montbarron, at Auxerre, in 1764.† The Abbat Hell maintains that all these were images formed by reflection in the eye-piece, in which way he could produce a satellite at will. No doubt some of the observations may be thus disposed of, but not at any rate Short's testimony, who, by using two telescopes, and at least four eye-pieces, rendered the Abbat's conditions for the illusion almost impossible. Humboldt classes it with the 'myths of an uncritical age.' Smyth inclines to an opposite opinion. Hind considers it 'a question of great interest,' and says it 'must remain open for future decision.'

Mädler tells a strange story about a number of brushes of

* The air was then so clear that two darkish spots were visible.

† Most of the observations have been discussed by Lambert in a special memoir, Astron. Jahrbuch, 1777.

light diverging from the circular side of the crescent Venus, lasting as long as the planet could be seen that evening, and remaining unaffected by any turning round or change of the eye-piece. He attempts no explanation, but thinks it could not have been an optical illusion. This is certainly *possible*, but it is an instructive instance of the oversights which may be incidental even to great philosophers, that it never seems to have occurred to him to try another telescope!

(For other facts, and Bianchini's diagram, see Appendix I.)

THE MOON.

(Abbreviations:—Schr., *Schröter.*— G., *Gruithuisen.*— L., *Lohrmann.*— B. & M., *Beer & Mädler.*—Schm., *Schmidt.*)

THE comparatively small distance of our satellite, 240,000 miles, renders it the easiest of telescopic objects. Its shadowed and irregular surface, visible to the naked eye, is well brought out even with a low magnifier; hence Galileo readily comprehended the nature of what his new and imperfect invention disclosed to him, and the smallest instrument will shew that freckled aspect, arising from numberless craters, which he compared to the eyes in a peacock's tail. Many a pleasant hour awaits the student in these wonderful regions; only, let him not expect that what he sees so plainly will be equally intelligible, excepting in its unquestionable relief from the effect of light and shade. Very overstrained ideas, as to the possibility of making out the minute details of the surface, have been entertained, not much more reasonable than those of the islanders of Teneriffe, whose simplicity led them to imagine that the telescope of Piazzi Smyth would shew their

favourite goats in our satellite; a very little consideration, however, will detect the absurdity of such anticipations. The first 'Moon Committee' of the British Association recommended a power of 1,000; few indeed are the instruments or the nights that will bear it; but when employed, what will be the result? Since increase of magnifying is equivalent to decrease of distance, we shall see the Moon as large (though not as distinct) as if it were 240 miles off, and any one can judge what could be made of the grandest building upon earth at that distance: very small objects, it is true, are perceptible from their shadows, but their nature remains unknown. Much difficulty too arises from the want of terrestrial analogies. It may be reasonably supposed that Venus or Mars, at the like distance, would be far more intelligible. We should probably not find them perfect transcripts of our own planet, for, as Schr. often remarks, variety of detail in unity of design is characteristic of creation; but we should have a fair chance of understanding much of what we saw. It is quite otherwise with the Moon. It is, in B. and M.'s words, no copy of the Earth; the absence of seas, rivers, atmosphere, vapours, and seasons,* bespeaks the absence of 'the busy haunts of men;' indeed of all terrestrial vitality, unless it be that of an insect or reptile. Whatever may be the features of the averted hemisphere, on which, as G. and Hansen have suggested, other relations may exist, we perceive on this side a mere alternation of level deserts and craggy wildernesses, all barren, and cold, and dead. The hope which

* This assertion must be limited to the subject in hand. It is not intended to deny the possibility of some kind of atmosphere, or fluid; and a trifling change of seasons must result from the slight inclination of the lunar axis.

cheered on G. and others, of discovering the footsteps of human intelligence, must be abandoned.* If it should be thought probable, as it very reasonably may, that the lunar surface is habitable in some way of its own, we have reason to suppose that, where the conditions of life are so extremely dissimilar, its traces would be as undecipherable by our experience as a brief inscription in a character utterly unknown. We ought not, in fact, to be surprised at such a difference between bodies belonging to distinct classes: it would have been unreasonable to have looked for a duplicate of a primary planet in its attendant. Waiving then any disappointment from this cause, we shall find the Moon a wonderful object of study. It presents to us a surface convulsed, upturned, and desolated by forces of the highest activity, the results of whose earliest outbreaks remain, not like those of the Earth, levelled by the fury of tempests, and smoothed by the flow of waters, but comparatively undegraded from their primitive sharpness even to the present hour. The ruggedness of the details, as old Hevel anticipated, becomes more evident with each increase of optical power, and we cannot doubt that we look upon the unchanged results of those gigantic operations which have stereotyped their record on nearly every region of the lunar globe.†

* The existence of many natural wonders on our own globe—for example, the *cañons*, or river-gorges, of NW. America, one of which has a length of 550 miles, an extreme depth of 7,000 ft., and a closest contraction of 100 ft.; or the obelisk of limestone, near Lanslebourg, 360 ft. high with a base of 40 ft. (Weld's 'Auvergne,' &c., p. 305), shews how cautiously inferences should be drawn as to the artificial origin of extraordinary appearances.

† This is sufficiently correct as a popular view of the subject; but a more careful examination may require it to be somewhat modified.

A brief general description of the phænomena of the Moon will prepare us for an examination of its topography. We have then

1. The *Grey Plains*, or *Seas* as they were formerly believed to be, and are still termed for convenience.* These are evidently dry flats—if the term 'flat' can be applied to surfaces shewing visibly the convexity of the globe—analogous to the deserts and prairies and pampas of the Earth. B. and M. find that they do not form portions of the same sphere, some lying deeper than others: they are usually of a darker hue than the elevated regions which bound them, but, with a strong general resemblance, each has frequently some peculiar characteristic of its own.

2. The *Mountain Chains, Hills*, and *Ridges*. These are of very various kinds: some are of vast continuous height and extent, some flattened into plateaus intersected by ravines, some rough with crowds of hillocks, some sharpened into detached and precipitous peaks. The common feature of the mountain-chains on the Earth, a greater steepness along one side, is very perceptible here, as though the strata had been tilted in a similar manner. Detached masses and solitary pyramids are scattered here and there upon the plains, frequently of a height and abruptness paralleled only in the most craggy regions of

The varieties of colour, if not arising from vegetation, may indicate an amount of 'weathering' which must be great from the distance at which it is perceptible: nor can we confidently affirm that with powerful telescopes no traces can be detected of the hand of time.

* Riccioli, when he recast the lunar nomenclature, and substituted the names of philosophers for the feeble geographical analogies of Hevel, retained the generic title of 'seas,' though he altered their designations. The reform attempted by G., who would have had them called 'surfaces,' has never taken effect.

the Earth.* Every gradation of cliff and ridge and hillock succeeds: among them a large number of narrow banks of slight elevation but surprising length,† extending for vast distances through level surfaces; these so frequently form lines of communication between more important objects,—uniting distant craters or mountains, and crowned at intervals by insulated hills,—that Schr. formerly, and B. and M. in modern times, have ascribed them to the horizontal working of an elastic force, which, when it reached a weaker portion of the surface, issued forth in a vertical upheaval or explosion. The fact of the communication is more obvious than the probability of the explanation.

3. The *Crater-Mountains*, comprising both the ridge and the included cavity. These are the grand peculiarities of the Moon: commonly, and probably with correctness, ascribed to volcanic agency: yet differing in several respects from the foci of eruption on our own globe: on the Earth, they are usually openings on the summits or sides of mountains—on the Moon, depressions below the adjacent surface, even when it is a plain or valley; on the Earth, the mass of the cone usually far exceeds the capacity of the crater—on the Moon, they are much nearer equality; on the Earth, they are commonly the sources of long lava-streams—on the Moon, traces of such outpourings are rare; on the Earth, their dimensions are comparatively inconsiderable—on the Moon, many of them are, the

* Schm. ascribes less rapidity to the gradients than is here supposed. Phillips, however, says, 'the steepness of the moon-crater walls and slopes is much greater in general than in any, except very rare examples, known among the volcanic regions of the earth.'—Phil. Trans. 1868.

† Schr. gives a length of 630 or 640 miles to a ridge connecting the spots Copernicus and Kirch.

grey plains excepted, among the largest of its features. When, however, allowance has been made for the inferior power of gravity on the Moon, through which a six-fold displacement in height or distance would be caused by the same amount of force,—for the possible difference of materials,—and for the more rapid cooling produced by radiation in the absence of an atmosphere, it is quite conceivable that volcanic force, similar to that on the Earth, may have been the real agent, though in a greatly modified form. Any one may see, with the ingenious Hooke, a strong resemblance to the rings left by gaseous bubbles; but to this impression mechanical difficulties arising from the cohesion of materials have been opposed, and a more consistent explanation sought in the idea that the larger craters may be the remains of molten lakes; in these, left for a while unfrozen in the general cooling and crusting over of the once-fiery globe, an alternate shrinking and overflowing of lava, from a fluctuating pressure from beneath, might gradually produce the existing forms. We have nothing on a corresponding scale on the Earth; but the craters of the Sandwich Islands, Kirauea and Haleakala, the one a fused, the other a frozen, lake of lava, with the small 'blowing-cones' which eject only cinders and ashes, afford an analogy,* the striking nature of which will be apparent from the following representation of the latter, taken from a view in Elwes's 'Sketcher's Tour.'† Difficulties no doubt remain, but we can hardly

* The craters of Java are also said to bear out this comparison.

† Haleakala, 'the house of the Sun,' in E. Maui, is of an oblong form, with two great openings in the wall, more than 30 miles in circumference, 10,000 feet above the sea, and about 2,000 feet deep. On the floor are 12 or 13 small red or yellow cones. The highest summits in the view are the two snowy volcanos of Hawaii, seen over the clouds in a very faint distance: our sketch gives only the general effect.

wonder at them, while geologists are still so little agreed about 'elevation-craters' and submarine volcanos on our own globe. The circular cavities of the Moon are arranged in three classes,—*Walled* (or *Bulwark*) *Plains*, *Ring-Mountains*, and

Extinct Crater of Haleakala. (See p. 62.)

Craters: a fourth includes little pits without, or with scarcely a visible ring. The second and third differ chiefly in size; but the first have a character of their own;—the perfect resemblance of their interiors to the grey plains, as though they had been originally deeper, but filled in subsequently with the same material; many of them in fact bearing evident marks of having been broken down and overflowed from the outside. Their colour is often suggestive of some kind of vegetation, though it is difficult to reconcile this with the apparent deficiency of air and water. It has been ingeniously suggested that a low stratum of carbonic acid gas—the frequent product of volcanos, and long surviving their activity *—may in such

* For instance, among the ancient craters of Auvergne, where it exists in great quantity.

situations support the life of some kind of plants: and the idea deserves to be borne in mind in studying the changes of relative brightness in some of these spots.* The deeper are usually the more concave craters; but the bottom is often flat, sometimes convex; and frequently shews subsequent disturbance, in ridges, hillocks, minute craters, or more generally, as the last effort of the eruption, central hills of various heights, but seldom attaining that of the wall, or even, according to Schm., the external level. The ring is usually steepest within (as in terrestrial craters),† and many times built up in vast terraces, frequently lying, Schm. says, in pairs divided by narrow ravines. Nasmyth refers these—not very probably—to successively decreasing explosions; in other cases he more reasonably ascribes them to the slipping down of materials upheaved too steeply to stand, and undermined by lava at their base, leaving visible breaches in the wall above: they would be well explained on the supposition just mentioned of fluctuating levels in a molten surface. Small transverse ridges occasionally descend from the ring—chiefly on the outside: great peaks often spring up like towers upon the wall; gateways at times break through the rampart, and in some cases are multiplied till the remaining piers of wall resemble the stones of a huge megalithic circle. A succession of eruptions may be constantly traced, in the repeated encroachment of rings on each other, where, as Schm. says, the ejected mate-

* G. thought he perceived, in the grey tints of depressed surfaces, some of which vary with the amount of solar light, traces of several kinds of vegetation, comprised between 65° N. and 55° S. latitude, and preserving the correspondence observed on the Earth between increasing latitude and elevation.

† Schm. gives 1° to 4°, and 20° to 50°, as the respective average inclinations without and within (the former, under-rated?).

rials seem to have been disturbed before they had time to harden: the largest are thus pointed out as the oldest craters, and the gradual decay of the explosive force, like that of many terrestrial volcanos, becomes unquestionable. The peculiar whiteness of the smaller craters may indicate something analogous to the difference between the earlier and later lavas of the Earth, or to the decomposition caused, as at Teneriffe, by acid vapours: in the grey levels, we thus perhaps obtain an indication of the superficial character of their colouring.

4. *Valleys*, of ordinary character, are not infrequent; some of grand dimensions; others mere contracted gorges. The most curious of these latter are entitled to be classed apart as

5. *Clefts* (or *Rills*). These were discovered by Schr.: G. and L. added to their number, which B. and M. raised to 90 in the text of their work; but the latter astronomer, on taking charge of the noble Dorpat achromatic, $9\frac{6}{10}$ in. aperture, perceived more than 150, and thought it might be possible to descry 1,000. Schm. has published (1866) a catalogue of 425, the greater part discovered by himself; and is making constant additions to it. These most singular furrows pass chiefly through levels, intersect craters (proving a more recent date), re-appear beyond obstructing mountains, as though carried through by a tunnel, and commence and terminate with little reference to any conspicuous feature of the neighbourhood. The idea of artificial formation is negatived by their magnitude;* they have been more probably referred to

* Schm. gives them 18 to 92 miles long, $\frac{1}{3}$ mile to $2\frac{4}{10}$ miles broad, and 100 to 430 yards deep. G., following out his strange theory that the Moon was once surrounded by an immense ocean which has wholly disappeared (whither ?), considered the larger of these furrows as the beds

cracks in a shrinking surface. The observations of Kunowsky, confirmed by M. at Dorpat, seem in some instances to point to a less intelligible origin in rows of minute contiguous craters; but a more rigorous scrutiny with the highest optical aid is yet required. To these we may add

6. *Faults*, or closed, not open, cracks, sometimes of considerable length, where the surface on one side is more elevated than on the other. These familiar geological features have been recognised in abundance by Birt and With, and are more readily traced on the Moon than on the Earth, from the absence of superincumbent alluvial deposits and denudation.

Wonders are here in abundance for the student: but he will find it impossible to pursue them far from the terminator,—they must be viewed under the oblique rays of a rising or setting Sun. As the angle of illumination increases, a fresh aspect of things creeps in and extends itself successively over the whole disc, and in its progress the inexperienced observer will find himself astonished at the change, and frequently bewildered in the attempt to trace out the landmarks of the surface. Objects well recognised while the relief of light and shade remains will become confused by a novel effect of local illumination, and the eye will wander over a wilderness of streaks and specks of light, and spots and clouds of darkness, where it may sometimes catch the whole, sometimes a portion, sometimes nothing, of many a familiar feature; while unknown configurations will stand boldly out defying all scrutiny, and keeping their post immoveably till the decreasing angle of

of dried-up rivers; the smaller he referred to artificial clearings in the forests, answering the purpose of roads. It is to be regretted that the extravagance of his fancy should have brought discredit upon the unquestionable precision of his sight.

illumination warns them to withdraw. Nothing can be more perplexing than this optical metamorphosis, so complete in parts as utterly to efface well-defined objects; so capricious as in some instances to obliterate one, and leave unaffected the other, of two similar and adjacent forms. G., carrying out an idea of Schr.'s, referred some of these changes to the progress of vegetation, which, if existing, will naturally, in default of a change of seasons, run its whole course in a single lunation: even the cautious B. and M. have admitted that some variations of colour may possibly point in this direction; and photographic results seem to indicate the presence of green light not cognisable by the eye: but the general change demands a more universal solution; and probably a wide range of colours in the soil may be concerned in the effect. The subject calls for careful study, but would involve much laborious application.*

The most obvious features of the Moon under a high illumination are the *Systems of Bright Streaks* which issue, though in widely differing proportions, chiefly from seven different centres: all craters, few inconsiderable, but none of the very largest class. In some cases the streaks proceed from a circular grey border surrounding the crater; in others they cross irregularly at its centre. They pass alike over mountain and valley, and even through the rings and cavities of craters, and seem to defy all scrutiny. Nichol asserts that in some contiguous systems, the order of formation may be detected from the mode of their intersection;† a statement well deserving the notice

* The polarization of light by the Moon was found by Secchi to be entirely different in the lowlands and in the mountainous parts. Birt remarks a greenish tint in the plains under very oblique illumination.

† The following, according to him, is the chronological order of three great systems: *Copernicus*, *Aristarchus*, *Kepler*.

of those whose telescopes will carry them through the enquiry. But one thing is certain, that they seldom, if ever, cause any visible deviation in the superficial level: a fact irreconcileable with Nasmyth's conjecture, that they are cracks diverging from a central explosion, filled up with molten matter from beneath; trap-dykes on the Earth are indeed apt to assume the form of the surface, but the chances against so general and exact a restoration of level, all along such multiplied and most irregular lines of exposure, would be incalculable: many of the rays are also far too long and broad for this supposition, or for that of B. and M., that they may be stains arising from highly heated subterraneous vapour on its way to the point of its escape.* The extraordinary brilliancy of some portions of the Full Moon is less difficult of explanation, when we bear in mind the effect of chalky strata, or that peculiar kind of granite which on the loftiest peaks of the Himalaya may readily be confounded with the adjacent snow. In many cases the form of the surface gives us no key to the distribution of this vivid reflection; in others it occupies a marked position, as on the summit of rings and central mountains: the idea of a mirror-like glaze, reflecting an image of the Sun, though entertained by such authorities as B. and M., seems difficult to be reconciled with the ever-varying angle of illumination.

A scale of reflective power has been adopted from Schr. by later selenographers, in which (blackness being 0) the darkest grey shades rank as 1°, the brightest portions 10°. This is of some use, though merely arbitrary. A more reliable plan,

* Schwabe suggests that they may be due to contrast: a shade being formed between them as the day increases by a multitude of thin parallel grey lines, which may be seen by a good instrument, and which may possibly result from some kind of vegetation.

especially in combination with such a scale, would be the mode of comparative values, in which the light of any given spot is referred to others above and below it in brightness. Changes are suspected in the reflective power of portions of the lunar surface, and it would be interesting to examine it in that aspect; but we have no good map of the Full Moon, and if we had, it never could well express the various gradations of brightness, which must be the object of topographical study.

A few *peculiarities of arrangement* deserve to be mentioned here. The remarkable tendency to circular forms, even where explosive action seems not to have been concerned, as in the bays of the so-called seas, is very obvious; and so are the horizontal lines of communication already mentioned. The gigantic craters or walled-plains often affect a meridional arrangement: three huge rows of this kind are very conspicuous, near the centre, and the E. and W. limb. A tendency to parallel direction has often a curious influence on the position of smaller objects; in many regions these chiefly point to the same quarter, usually N. and S., or NE. and SW.; thus in one vicinity (between **G**, **L**, and **M***) B. and M. speak of 30 objects following a parallel arrangement, for one turned any other way; even small craters entangled in such general pressures (as round **L**), have been squeezed into an oval form; and the effect is like that of an oblique strain upon the pattern of a loosely-woven fabric: an instance (near **27**, **28**) of double parallelism, like that of a net, is mentioned, with crossing lines from SSW. and SE. Local repetitions frequently occur; one region (between **290** and **292**) is characterised by exaggerated central hills of craters; another (**A**) is without them; in another (**185**), the walls themselves fail. Incom-

* References to Map of Moon.

plete rings are much more common towards the N. than the S. pole; the defect is usually in the N., seldom in the W. part of the circle; sometimes a cluster of craters are all breached on the same side (near **23, 32**).* Two similar craters often lie N. and S. of each other, and near them is frequently a corresponding duplicate. Two large craters occasionally lie N. and S., of greatly resembling character, S. usually $\frac{3}{4}$ of size of N., from 18 to 36 miles apart, and connected by ridges pointing in a SW. direction (**20, 19**: **78, 77**: **83, 84**: **102, 103**: **208, 207, 204**: **239, 242**: **261, 260**: **262, 263**: **340, 345**). Several of these arrangements are the more remarkable, as we know of nothing similar on the Earth.

The question as to the *continuance of eruptive action* on the Moon is one of great interest. It is now generally understood that the volcanos, which Herschel I. and others thought they saw in activity on the dark side, were only the brighter spots reflecting back to us the earth-shine of the lunar night with the same proportional vivacity as the sunshine of the day. No valid reason indeed has been assigned for the fact, witnessed by many observers, especially Sm., that one at least of these spots,—Aristarchus,—varies remarkably in nightly luminosity at different periods,† nor for the specks of light which more

* Compare Elwes's account of the small cones on the floor of the great extinct crater Haleakala, some of them 'broken down at the side, nearly always on the NE.'—Sketcher's Tour, 214.

† Elger saw a spot on the dark side, apparently Aristarchus, 1867, April 12, $7^h\ 30^m$ to $8^h\ 30^m$, nearly as bright as a 7 mag. star, with a 4-in. aperture, and too conspicuous to be overlooked by the most careless observer. It was much fainter during the last 15^m, and scarcely perceptible at 9^h. The Moon was $1^d\ 5^h$ after I. Qu. He had seen something similar on former occasions. Schr.'s conjecture that the variations, which he observed in a minor degree in several parts of the disc,

than once Schr. caught sight of on the dark side for a short time :* but in these cases there has been no subsequent perceptible alteration of surface; and they furnish no reply to the enquiry respecting present changes. Such were abundantly recorded by Schr. in his day, chiefly variations in the visibility or form of minute objects; but a great majority of them he, and subsequently G., who witnessed many such appearances, referred to the lunar atmosphere : and B. and M. are disposed to discard them all as the result of inaccuracy or varying illumination. The extraordinary influence of the latter upon the aspect of distant and unknown objects may be estimated by anyone who will sketch the changed effects of light and shade on any familiar terrestrial object at different times of day; still there seems to be a residuum of minute variations not thus disposed of, and in some cases possibly indicating actual local change. Terrestrial analogy is in favour of the idea that disturbing agency may have greatly diminished without having become extinct: but observation, not assertion, must decide the point. There are no traces of any grand convulsion since the date of the first lunar map; and we are scarcely as yet possessed of the means of detecting smaller changes. Schr.'s drawings are very rough; the much more careful ones of L., and B. and M., would be too recent to warrant great expectations, even were they more reliable—especially the latter—as to minute details : the great map of Schm., 6 Paris f. in diameter, which will be crowded with minutiæ—a wonderful specimen of persevering industry—is not yet published.

may be due to atmospheric condensation during the lunar night, is more elegant than probable : it may however deserve consideration.

* Such a phænomenon, more extended but very faint, was seen, or fancied, by G.; and recently witnessed, with great distinctness, by Grover and by Williams.

Topographical studies, however, after the manner of Schr., giving repeated views of the same object under differing angles of illumination and reflection, are the only satisfactory means of detecting possible change. We have as yet no monograph representing any one spot for every successive night of its visibility; but such a connected series would be very instructive. The catalogue of objects and attendant map on a scale of 200 inches, now in preparation by Birt, is laying a foundation, of a very different character from any which have preceded it, for an adequate knowledge of our satellite. In the meanwhile the beautiful and not expensive map of B. and M. may be advantageously employed, though not implicitly trusted: to this their explanatory work 'Der Mond' (The Moon) is an important addition for the German scholar. A book with the same title by Schm. (1856) is most interesting and valuable, and ought to appear in an English dress.

Little of a satisfactory nature can be said as to a *Lunar Atmosphere.* That it must be far rarer than any known gas is demonstrable from theory, and proved by observation, which shews us a sharply defined outline, and detects no refraction in stars over which the Moon passes:* and hence its entire absence has been maintained by great astronomers: Schr. asserted its existence from many changes of aspect in minute objects, and from a very dim twilight which he traced through 9 years beyond the points of the horns; his inferences are supported and in part exceeded by G., who frequently saw—or imagined—fogs and clouds on the surface. Schr. explains the defined limb and the absence of refraction by limiting

* It has been recently ascertained that the Moon's observed exceeds by 4″ its computed diameter. Airy thinks however that this may be explained by irradiation.

the atmosphere to the inferior regions, and leaving the higher grounds free. B. and M., while explaining away—not very satisfactorily—Schr.'s twilight, which they could never distinctly find, d... ...e possibility of a very rarefied gaseous envelop... ...ilight, which G. confirms, and whi... ...o, but only doubtfully fro... ...en-gage the stu...

a... ...s.

...92,

...61.

...have ...le that ...ould be ...l craters ...tances (to ...rder to the ...hrown from ...d occasional ...rs. In a few ...points on the ...ry spectrum' of ...it is difficult to ...atmosphere.

Occultations of planets or stars, which are important to the professed astronomer, are interesting to the amateur as bringing out distances and motions of which the naked eye takes little cognizance: the comparative nearness of our satellite becomes self-evident, and its orbital movement is made apparent from minute to minute. A grand effect is produced by the visible sailing of this ponderous globe through immeasurable space; and it may well convey a deep impression of the omnipotent Power and consummate Wisdom which orders its undeviating course. The instantaneous extinction, too, and sudden flashing out of a large star in these circumstances are very striking, though less instructive than might have been expected as to the question of an atmosphere: the immersion and emersion are usually as sudden as if none existed; but this may be accounted for by the rapid motion of the Moon, or, on Schr.'s theory, by the elevation of that portion of the limb: the gradual extinction sometimes recorded may be only due to irregularities on the edge: the distortions or flattenings occasionally noticed in the shape of planets at occultation are too extensive for any such cause, and must be referred to optical illusion.* All occultations of importance are predicted in the Nautical Almanac; the most beautiful are *immersions* behind the *dark* limb when the latter receives a strong earth-light, as between New Moon and I. Quarter.†

The *projection* of a star upon the Moon, just before immersion, as if it advanced in front of it, is very difficult of expla-

* See Proctor's very ingenious illustration of such deceptions under the head of *Saturn*.

† Kunowsky has seen the dark limb sharply defined $3^d\ 4^h$ after I. Quarter. G. professed that he was able to trace the larger seas on the dark side with the naked eye.

nation. South, after a careful examination of the instances on record, was unable to come to any satisfactory conclusion: it is an occurrence of the most capricious kind, which can never be predicted for any star, eye, or telescope; and is evidently an optical, not astronomical, phænomenon.

Libration must be well understood, before proceeding to topography. This is an apparent displacement of the spots with respect to the limb (or centre), arising in one direction (that of lunar longitude) from the equable rotation of the Moon on its axis combined with its unequable velocity in an elliptical orbit, in another direction (that of latitude) from the inclination of its orbit to the ecliptic in conjunction with a slight inclination of the axis to the plane of the orbit: it completes its changes in about four weeks, though an exact restoration of the position called 'mean (or medium) libration' does not take place till the end of three years. Hence, though we are commonly said to see always the same hemisphere, it is only approximately true. The spots are constantly swinging a little backwards and forwards, and those near the E. and W. limbs going alternately out of sight; while, as our eye rises successively above each pole, a little more or less of those regions is seen,—the whole area thus concealed and exposed by turns amounting to $\frac{1}{7}$ of the surface of the globe. No map of the Moon, therefore, can correctly represent its whole aspect on two following nights, and they are of course constructed to correspond with a state of mean libration. The displacement of the spots, which amounts at a maximum to 6° 47′ N. and S., 7° 55′ E. and W., and 10° 24′ from a concurrence of both, in either direction from a normal position, produces little effect upon the aspect of the central parts, which are merely shifted with regard to the Moon's equator or 1st meridian; but in the

foreshortened neighbourhood of the limb its results are very obvious. Fresh regions constantly take the outline of the disc, and the mountainous projections of to-night may be all out of sight to-morrow. One effect of libration is, that the spots have no fixed position with respect to the Moon's age, being sometimes earlier, sometimes later on the terminator, so that no precise instructions can be given when to look for them: it may be useful however to know that, as Birt has pointed out, the terminator passes through very nearly the same part of the surface at recurring intervals of $59^{d}\ 1^{h}\ 28^{m}$. A few approximations alone will be found in these pages, especially as a little practice with the map will render identification easy: the following considerations, however, may be useful to the beginner.

The relief of the surface will be stronger as it is nearer to the terminator, and all delicate and difficult objects are best seen near the sunrise or sunset of the Moon, which, like the corresponding times of the Earth, abound with grand and beautiful effects of light and shade. Every little irregularity then assumes temporary importance; inconsiderable hillocks, minute craters, low banks, narrow canals, become visible in the horizontal ray; rising grounds or soft valleys seem to start into existence, the outer slopes of craters advance into the surrounding levels, larger masses appear in exaggerated prominence,

'Majoresque cadunt de montibus umbræ.'

These broad and deep shadows often taper off to such slender points, that a caution may be requisite, not to infer anything extravagant respecting the sharpness of the form which casts them. It may be questioned whether anything in the Moon

exceeds the acuteness of the Swiss Finsteraarhorn, or the abruptness of the Pic du Midi d'Ossau in the Pyrenees. An oblique light cast upon a rough surface, modelled in clay or dough, will shew how disproportioned oftentimes is the shadow to the reality; and the same experiment will prove to us that in many cases the true relief will be unknown till the shadow on each side of the object has been examined. The intense blackness of the lunar shadows gives an effect which must be strangely contrasted with a distant prospect of our Earth. Here, a highly reflective and vapour-charged atmosphere surrounds all objects with a constant illumination, beginning before sunrise and outlasting sunset: there, the Sun goes up and down in noon-day strength, and the shadows are unrelieved by any reflection from a sky which must be almost black all day: every mountain produces utter darkness where it intercepts the Sun, and every crater, while its ring is glittering like snow in the rising or setting beam, is filled with midnight shade. Dawes, alone, by employing the contracted field of his solar eye-piece, has traced a very faint glimmering in these depths, produced by reflection, not from the atmosphere, but the cliffs above, illuminated by the full sunshine. The terminator is indeed marked through the grey plains by a narrow shadowy border, and the tops of the mountains just appearing or vanishing in the night-side are somewhat deficient in brightness; but this is the 'penumbra,' or partial illumination, due to a portion of the Sun's disc, while the rest is beneath the horizon. In other respects the glittering sharpness of the Moon's sunrise, or sunset, is widely contrasted with the softness of our own skies. But though it is then that we must watch for minute details, for large objects we shall find the relief too broad and partial; unbroken night

conceals the greater cavities, and the shade of loftier summits renders lower ranges invisible. Not till day descends among the terraces of the one, or creeps down over the shoulders and along the slopes of the other, does their true structure come out; and their distinctness increases while their minuter neighbours decline into insignificance.

L.,* and B. and M., have done admirably well in their delineations. Yet a little experience will shew that they have not represented all that may sometimes be seen with a good common telescope. My own opportunities, even when limited to a $3\frac{7}{10}$in. aperture, satisfied me, not only how much remains to be done, but how much a little willing perseverance might do, provided there were some knowledge of the laws of perspective and shadow, and a due attention to the direction of the incident and reflected light: some facility in design would also be very desirable, and if proportion is tolerably preserved, a number of rough sketches under varied lights would be more serviceable than one or two finished drawings. Detail being the great object, a small portion only should be attempted at once; this will not merely be easier and more pleasant, but will avoid the change in the shadows, which is considerable near the terminator during a long-continued delineation. The record, to be of value, must possess four data: 1. *Hour of Observation*;—2. *Moon's Age*, reckoned from or to the nearest change;—3. *Position of Terminator* referred to well-marked spots, some nearly in the latitude of the observed region; others a good way N. and S. of it, so as to shew the

* His general map is valuable, and not expensive, but the scale, $15\frac{1}{4}$ inches, is rather small, and the deviations from circularity in the craters exaggerated. The discontinuance of his 'Sections,' from failing sight, was a serious hindrance to selenography.

direction of illumination, which is seldom exactly at right angles to the lunar meridian;—4. *Libration*, indicated (i) in longitude, by time reckoned to or from nearest perige or apoge; or both may be specified; (ii) in latitude, by Moon's latitude at the time; these particulars being taken from Nautical Almanac, and the last reduced to the hour of observation. More than this cannot be ascertained without a micrometer; but this is enough for the comparison of delineations. If the last two data are nearly coincident in any observations, the angles under which the landscape is illuminated and viewed differ so little that any variation in its details must be referred to either—1. inadvertence or mistake in the observer;—2. actual change in the Moon's surface; or 3. obscuration or deception in her atmosphere. Schr. relates so many instances of the latter kind that, even if we reject the confirmation of the keen-eyed but fanciful G., it seems difficult to follow B. and M. in disposing of them all as errors of observation; nor should the enquiry be thought unworthy of notice. One important caution seems not to have occurred to Schr.: the change of lunar seasons, slight as it is, somewhat affects the direction of the shadows: and the variations of foreshortening from libration may make them more or less visible: and thus some apparent discrepancies might be reconciled. With large apertures, a lightly tinted screen-glass works well: possibly the use of different colours might bring out some curious result.*

A good popular Map of the Moon has been hitherto a desideratum in England. B. and M.'s smaller map, though very inexpensive, is scarcely known here; and is rather crowded.

* See De La Rue, on increased distinctness during advance of lunar eclipse, in *Monthly Notices*, xxv. 276.

Russell's and Blunt's, striking as to general effect, break down in details. Those in ordinary books of astronomy are especially useless. The one here given will, it is hoped, be found less defective: it makes no claim to pictorial resemblance, and professes to be merely a guide to such of the more interesting features as common telescopes will reach. It is carefully reduced from the 'Mappa Selenographica' of B. and M., published in four sheets in 1834, and lately re-edited, on a scale of 3 f. 1¼ in. (3 French f.), omitting an immense mass of detail accumulated by their diligent perseverance,* which would only serve to perplex the beginner. Selection was difficult in such a crowd; on the whole it seemed best to include every object distinguished by an *independent name*, including the recent additions; many of little interest thus creep in, and many sufficiently remarkable ones drop out; but the line must have been drawn somewhere, and perhaps would have been nowhere better chosen for the student. Other spots, however, have been admitted from their conspicuousness, to which B. and M. have given only a *subordinate* name; minuter details come in, in places, for ready identification; elsewhere, larger objects are passed by, as less useful for the purpose of the map. The nomenclature is that established by B. and M. Hevel (or Hevelius), in the earliest attempt, designated different regions of the Moon from supposed geographical analogies; but this system has long been abandoned, except in the case of some mountain ranges. Riccioli, a far inferior observer, adopted a more available method of affixing to the

* Some idea may be formed of this, from the 919 micrometrical measures of the position of spots, and 1,095 of heights and depths, contained in their work 'Der Mond.' Schm., a worthy follower, has made more than 1,000 drawings and 3,000 height-measures.

larger spots the names of distinguished philosophers; his list was increased by Schr., who made each name include the adjacent objects, by adding the letters of the alphabet; and this system, improved and generalised, has been applied by B. and M. to the whole disc; the name used alone, distinguishes the principal object; Greek or Roman letters added to it signify respectively the elevations or hollows in the vicinity. A mode admitting of much greater accuracy is adopted in the standard catalogue now being formed by Birt, who, in conjunction with the late Dr. Lee, has introduced many additional names. To avoid crowding our map, letters and numbers are substituted for names; every object in the descriptive notices will be thus referred to, but as this selection is limited, a complete list of the names given by B. and M., with Birt's additions (commencing with No. **405**), is subjoined, which will also secure, in all cases, the important object of identification as far as it goes. The alphabetical arrangement which follows it may be found convenient.

The points of the *Lunar Compass* must be mastered before we can use the map. Astronomers have fixed these from their relative, not intrinsic, position; that is, the several portions of the disc are named from the adjacent quarter of the sky when the moon is on the meridian. Hence N. and S. occupy the top and bottom, but E. and W. are reversed, as compared with terrestrial maps: the former being to the left, the latter to the right. But maps of the Moon usually represent its telescopic, that is, inverted appearance, so that we shall find S. at top, N. at bottom, E. to right, W. to left. The meridians and parallels of latitude have been omitted, except the 1st Meridian and Equator, which divide it, like the original, into Four Quadrants: these are called by B. and M., the 1st or

NW., 2nd or NE., 3rd or SE., 4th or SW. Quadrant. A selection of the most interesting objects in each follows, from materials furnished by the 'Mond' of these astronomers, and retaining their arrangement: additions are made from other sources; but all statements not otherwise authenticated depend upon their authority. In the more remarkable instances, their measures of height and depth are given; these were ascertained by the lengths of the shadows, a method previously employed with less accuracy by Schr.; capable of much precision on favourable ground, but elsewhere uncertain. For our present purpose round numbers will be a fully sufficient approximation.*

First, or North-west Quadrant.

Mare Crisium (**A** on the map). We begin with a conspicuous dark plain, the most completely bounded on the Moon, and visible to the naked eye: apparently elliptical from foreshortening, but really oval the other way, being about 280 m. from N. to S., 354 from E. to W., and containing about 78,000 square m., or $\frac{1}{111}$th part of the visible hemisphere—more than half as much again as the area of England and Wales. Its grey hue has a trace of green in the Full; this has also been represented by the present talented Astronomer Royal for Scotland, C. Piazzi Smyth, in two beautiful figures taken during the increase and wane. On rare occasions it has been seen by Schr., and in part by B. and M., speckled with minute dots and streaks of light: something of this kind I saw with a fluid achromatic, 1832, July 4, near I. Quarter. A similar

* Minuteness of numerical detail in astronomical results should not be misunderstood. It represents no natural fact, but only the care bestowed upon measurement.

appearance was noticed by Slack, and Ingall, 1865. It would be difficult to say why, if these are permanent, they are so seldom visible—a suggestive, though at present unintelligible, phænomenon. The surface is deeply depressed, lower than Mare Fœcunditatis and M. Tranquillitatis. The boundary mountains are in part very steep and lofty. The PROMONTORIUM AGARUM (**1**) rises about 11,000 f.; a mountain SE. of Picard 15,600 f., rivalling our Mont Blanc. On W. edge, Schr. delineated a crater called by him ALHAZEN, which he constantly employed to measure the existing libration: he saw in it after a time unaccountable changes, and since, it has been said, it cannot be made out. B. and M. think he confounded it with a crater (**2**) lying further S.; the question, which was debated between Kunowsky and Köhler, has been cleared up by Birt, who has recovered Schr.'s crater, between two lofty mountains; the cause, however, of its greater obviousness in Schr.'s earlier days still offers some difficulty. The plain contains some moderate-sized craters—the largest, PICARD (**4**), S. of which G. saw some curious regular white ridges like ramparts; while on the W., Birt and Ingall have pointed out a remarkable bright patch; with symptoms of change. The next crater N. (PICARD A) has a very minute interior crater, discovered by Schm.—a test-object. There are also several very minute craters in the level. Near the E. edge, where there is a pass in the great surrounding ridge between **450** and **451**, lie several small, but in part lofty mountains,*—islands, as it were;—among these Schr. describes singular changes, which he refers to an atmosphere; B. and M. consider them merely varied illumination, or pass them by as unworthy of attention. Succeeding observers may

* These are ill-figured in the great map, and B. and M. have given a separate representation of them in their 'Mond.'

revise, even if they ultimately acquiesce in, this summary decision. Schr. was a bad draughtsman, used an inferior measuring apparatus, and now and then made considerable mistakes; but I have never closed the simple and candid record of his most zealous labours with any feeling approaching to contempt; and though there may be truth in the assertion of B. and M., that he was biassed by the desire of discovering changes, they, possibly, were not themselves free from an opposite prepossession.

Central hills are absent from the craters of this district.

A may be well seen about 5^d after New, or 3^d after Full; in the latter case it is a magnificent spectacle when crossed by the terminator and partially covered in by the vast shadows of the mountains, from which Schr. considered that those on NE. side must be at least 16,000 or 17,000 f. high.

This astronomer has inserted in his work a marvellous observation by Eysenhard, a pupil of Lambert, 1774, July 25. The night being perfectly clear, he saw with a common 4 f. refractor four bright spots in **A**, then intersected by the terminator, two of which only—those on the day-side—can be identified; after noticing them at times for 2^h, he found all at once that the part of the terminator in **A** had a slow reciprocating motion, completed in 5 or 6^m, between these pairs of spots, each pair being touched by it in turn. Two other refractors of 7 and 12 f. shewed this appearance with equal distinctness, and it was observed for 2^h, the terminator in **X** remaining perfectly still. This is a very strange story, yet Lambert seems to have believed it; and perhaps we cannot pronounce it wholly incredible in the face of an equally wonderful and perfectly well-attested retrogression in a satellite of Jupiter, to be described hereafter.

Between FIRMICUS (**7**) and the limb, half-way in mean libration, are some curved dark streaks (*Paludes Amaræ*, Hevel,) in which B. and M. found singular variations, resulting, as they admit, possibly (not probably) from periodical vegetation.

CLEOMEDES (**12**), a walled plain 78 m. in diameter, includes a small crater (Cleomedes A), brilliant, but not always alike defined, in Full; Schr. had found it not always equally visible. He speaks of many variations in the interior level, which he represents rather differently from B. and M.—G. found its W. part marked out into many rhomboids—squares in perspective.

BURCKHARDT (**19**), 35 m. in diameter, lies 12,700 f. below its E. wall.

GEMINUS (**20**), 54 m. broad, has a ring 12,300* f. high on E., 16,700 f. on W. side.

BERNOUILLI (**21**), equally deep, is very precipitous.

GAUSS (**22**) is a walled plain, 110 m. long. B. and M. describe the fine effect of sunset upon its ring. It has a grand central mountain, which must at times command a glorious view, across a plain of 50 m. covered with night, to illuminated peaks all round the horizon, above which the Sun on one side, and the Earth on the other, are slowly coming into sight.

STRUVE (**25**), a slight depression, is remarkably dark in Full.

ENDYMION (**27**), a walled plain 78 m. in diameter, is, in some states of libration, very dark in Full: the irregular wall rises W. to more than 15,000 f., overtopping all but the very highest peaks of our Alps. I have seen it in grand relief $3^d\ 7^h$

* By a singular coincidence, in reducing as usual French to English measure, the resulting number was 1, 2, 3, 4, 5, with 6 in the first place of decimals. The chances against such a sequence must have been extremely great: but it exemplifies a principle, not always kept in mind, that so long as a thing is *possible*, it must *sometimes* occur.

after New, 2ᵈ 9ʰ after Full. Between **27**, **28**, and **29** is a curious double parallelism, objects all ranging SSW. or SE.

ATLAS (**28**). A superb amphitheatre 55 m. broad, 460 square m. in area; its ring rich in terraces and towers, rising 11,000 f. on N.; a very dark speck in interior, where I have also seen some clefts, with Bird's 12 in. silvered reflector.

HERCULES (**29**). A worthy companion to it, 46 m. across. The ring, in places double, includes a small crater of subsequent date. Look for this pair 5 or 6^d after New, $3\frac{1}{2}^d$ after Full.

FRANKLIN (**32**). Several incomplete rings lie hereabout, all open N.

MARE HUMBOLDTIANUM (**B**), discovered by B. and M.,* is rather more than half as large as M. Crisium, but close to the limb, above which the peaks of its W. border sometimes appear in profile, in one part 16,000 f. high.

In this region, in certain states of libration, occur two singular flattenings of the limb, divided by a ridge. These, with another, were discovered by Key, 1863. One of them extends for 10°.

MOUNT TAURUS (**51**) is a lofty range, containing the terraced crater RŒMER (**52**), 26 m. wide, 11,600 f. deep.

POSIDONIUS (**54**). This walled plain, nearly 62 m. across,

* Part, however, is shewn on Russell's Lunar Globe (1797), beautiful as a work of art, poor in detail. A larger globe by the same observer, in relief, is preserved in the S. Kensington Museum. Mme. Mädler modelled a lunar globe in wax. Mme. Witte, a Hanoverian lady, has completed a very perfect globe in relief, from B. & M.'s observations and her own. There is at Bonn a magnificent relief of the Moon, 18 Paris f. in diameter, executed under Schm.'s direction by Dickert (1854). Sir Chr. Wren, when Savilian Professor at Oxford, made a lunar globe in relief at the request of the Royal Society and by command of Charles II., who placed it in his cabinet. It is to be hoped that it has been carefully preserved.

includes several small details, in which Schr. found repeated changes: the shadow in the bright little crater was abnormal in length, and once replaced by a grey veil. B. and M. never saw anything unusual. Schm. appears to have found it once (Feb. 1849) shadowless. It has been finely drawn (*English Mechanic*, 1872, Mar. 1) by Gaudibert, who sees a cleft in it. A good object about 6^d after New.

LITTROW (**55**) and MARALDI (**56**) shew the SSW. parallelism of the vicinity: VITRUVIUS (**57**), with a very dark interior, lies in a mottled region, in one place slightly tinged with blue.

[MOUNT ARGÆUS] (**58**). A small range gradually rising from W. to a summit, ranked by Schr. as high as the loftiest of our Pyrenees, and then sinking, on its NE. face, in an amazing precipice, down to the wide plain. It is remarkable for the spire of shade which it casts at sunrise; but it has been unfairly treated by B. and M., being omitted from their nomenclature, which contains many very inferior hills: as it is so interesting an object, I hope I am not guilty of presumption in assigning a name to it, chosen from its vicinity to **51**. It requires close watching, as the shadow rapidly loses its slender point; look for it when the ring of **61** just heaves in sight beyond the terminator. I have seen it thus 4^d 21^h after New.

MACROBIUS (**59**), nearly 42 m. broad, sinks almost 13,000 f.

PROCLUS (**60**) has a ring, next to **148** the most luminous part of the Moon; yet scarcely ever visible on the dark side; very much less so than many duller objects. B. and M. ascribe this to the narrowness of the wall. It is the centre of several bright streaks, not very easily seen.

PALUS SOMNII (**F**), an uneven, defined, always distinguishable surface, has a peculiar tint, perhaps yellowish-brown, unlike the simple grey of MARE TRANQUILLITATIS (**G**).

Plinius (**61**). A terraced ring, 32 m. in diameter, filled with hillocks.

Menelaus (**70**). A very steep crater about 6,600 f. deep; with a ring very brilliant in Full. All the ridges running from it trend SW., and this parallelism reaches over a great district, including most of **85**, **68**, **L**, and the vicinity. Several bright streaks issue from **70**—one is a continuation of a ray from **180**, extending in all more than 1,850 m. Here was one of Herschel I.'s pseudo-volcanos.

Mare Serenitatis (**H**). This wide and beautiful plain is nearly circular, about 432 m. from N. to S., 423 from E. to W.; the interior appeared at Full to B. and M. of a clear light green, unnoticed by Schr. and L., and not easily seen even by its discoverers; it is set in a border of dark grey, and bisected by a straight whitish streak, invisible, like all of its class, near the terminator. Towards the W. edge of the plain is a curious long low serpentine ridge, discovered and figured by Schr., but only well seen from its shadow near the terminator. I have found it thus between 5 and 6^d after New. A little E. of it I have seen a lower one with reverse flexures.

Linné (**74**). A small crater, described by L. as 'very deep,' and by B. and M. as 'deep,' but discovered by Schm. to have entirely lost that character, and to resemble a *whitish cloud*, surrounding a most minute crater. This very interesting spot has undergone a rigorous scrutiny, and opinions are still divided, owing to some want of explicitness in the earlier records. But how many spots would have been more carefully observed, could it have been foreseen that questions would subsequently be raised about them!

Caucasus (**75**). This grand mountain mass rises into insulated peaks, suitably termed 'aiguilles' by B. and M., as

lofty as any on the Moon, those on the limbs excepted, and reaching 18,000 or 19,000 f. Their narrow shadows are drawn out into fine points—a superb spectacle, which I have seen about I. Quarter. Craters are very rare here.

EUDOXUS (**77**) and ARISTOTELES (**78**). A noble pair of craters, not easily found in Full, in a region sprinkled as it were with luminous dust. The terraced wall of **77**, 11,300 f. above the W. interior, is on that side crowned by two turrets of 15,000 f. Etna, as Schr. observes, would stand in this great cavity. **78** is more than 50 m. broad, nearly as deep as **77**, but with a much richer wall. The interior of both resembles the surrounding country more than is usual. **78** is very remarkable for rows of minute hillocks lying NE., NW., and SW., in lines pointing to the crater—the finest specimen of this not uncommon arrangement: it is less distinct round **77**. It requires very favourable light, and is difficult for the student. I have seen it, with wide SW. libration, about I. Quarter. S. and SW. of **77** the surface down to **H** is thronged with hillocks innumerable: on E. they reach to **75**. Many small craters and a little cleft near **78** are omitted by B. and M.

WEDGE-SHAPED VALLEY OF ALPS. An extraordinary cleft, figured by Bianchini in his work on Venus; a circumstance unnoticed alike by Schr., B. and M., and Schm. About 83 m. long, and from 3½ to 5¾ m. broad, it breaks in a straight line through the very loftiest Alps, with precipitous sides and a depth of at least 11,500 f., in which Mont Perdu or the Vignemale of the Pyrenees would disappear. It is always easily found.* Between this valley, **79** and **I**, lies a curious region all sprinkled with hillocks: B. and M. estimated them at 700

* It has never been well figured; the rough sketch of Schr. is truer than the elaborate designs of L., and B. and M. An illustrative diagram will be found in *Intellectual Observer*, vii. 174.

or 800 at least. I once saw them finely developed at I. Quarter, in a 20 f. achromatic by Slater, of 14¾ in. aperture.

ALPS (80). A lofty and exceedingly steep chain, rising into separate peaks: one of the highest, the Mont Blanc of Schr. (next to which our number stands), reaches, he says, to 14,000 f. B. and M. reduce it below 12,000 f. Close beneath its E. foot, Schr. perceived, 1788, Sept. 26, on the dark side of the Moon, a small speck of light, like a 5 mag. star to the naked eye, which having been verified in position, and kept in view for fully 15^m, disappeared irrecoverably: the round shadow, sometimes black, at others grey, which he subsequently found in the day-side in or near its place, was probably nothing new.

A copy of his figure is here given. Strange to say, 1865, Jan. 1, Grover recovered this bright spot, or one very near its site, with only 2 in. of aperture, and saw it unchanged as a 4 mag. star to naked eye, but rather larger, for fully 30 m.

PALUS NEBULARUM (I) and PALUS PUTREDINIS (K) are for the most part so level, that mounds of 50 or 60 f. would be rendered visible by their shadows near the terminator.

CASSINI (81). A curious ring-plain; the narrow wall encloses a scarcely depressed space, and a small deep crater, which has a considerable irregularity within, unnoticed by B. and M. but not new, as I saw traces of it in 1826. The ring casts long spires of shade about I. Quarter.

THEÆTETUS (82) would take in Snowdon twice over, with still depth to spare.

ARISTILLUS (**83**), a very grand crater, 34 m. broad, 11,000 f. deep on E. side, has a fine central mountain, which I saw with $5\frac{1}{2}$ in. of aperture as three parallel ridges. The ring stands up nobly from the plain, and is flanked on all sides (as Schr. perceived) by radiating banks resembling lava-streams, or currents of ejected blocks or scoriæ,* evidently posterior to the surrounding level; in suggestive contrast to **120**. I have seen them well about 1^d after I. Quarter.

AUTOLYCUS (**84**), its smaller companion, is nearly as deep, with a similar but less evident radiation. This pair of craters illustrates a not uncommon arrangement, of two rings in the same meridian; very similar in every respect; if unequal, in diameter as 3 to 4, and the smaller lying S.; from 18 to 36 m. apart; and connected by low ridges running SW.

APENNINES (**85**). This very extensive chain is more like the mountains of the Earth than is usually the case.† Its length, according to Schr., is nearly 460 m., great part of it lying in the next Quadrant. Its SW. side ascends gradually —the opposite aspect breaks down at once in awful precipices of stupendous height, casting a shade through 83 m., or losing the last ray as far beyond the terminator. Huygens (**90**), the loftiest peak, rises, according to Schr., no bad measurer, to 21,000 f. B. and M. think he confounded two adjacent summits, and give 18,000 f.: in either case a superb elevation, greatly overtopping our Mont Blanc, perhaps rivalling Chimborazo. On its apex is a minute crater. Other summits, though inferior, are yet of extraordinary height and steepness:

* The volcanos of Java have all ribbed sides; but these are ascribed to erosion by torrents.

† Schm. however considers the resemblance not striking, and justly notes the absence of depressions similar to terrestrial river-valleys.

Hadley (**87**), facing **75**, 15,000 f.—Bradley (**89**) 13,000 f.—Wolf (**92**) 11,000 f. The gradual entrance of the range into sunshine about I. Quarter is a glorious spectacle; and its projection into the dark side, which may be seen without telescopic aid, probably gave rise to the early idea mentioned by Plutarch, that the Moon was mountainous: from its abruptness it does not lose all traces of shade till 24^h before Full. With very few craters, it consists of ridges and peaks not to be numbered by thousands in large instruments: Schr. detected this; M. says it would take the opportunities of three or four years to delineate all the details which a power of 800 or 1,000 will shew.

Cleft of Hyginus. A fine specimen of these furrows lies fortunately in an excellent position in the Mare Vaporum (**L**), a tract, of which the dusky streakiness has often interested me about I. Quarter. The cleft is conspicuous enough to yield to a power of 40 in a good telescope, under any illumination. It begins from NE. at the foot of a long low hill, as a flat valley about $1\frac{1}{2}$ m. wide by 9 m. long, where I have found (with $5\frac{1}{2}$ in. aperture) that it receives a branch from E.: having then contracted to about $\frac{3}{4}$ m. with precipitous sides and great proportionate depth, it passes through four minute craters, bends a little, receives another short branch from E., and traverses Hyginus (**93**), but at a lower level, and as a bank. B. and M. once saw, in the wane, its edges bridging the black cavity as two narrow bright lines: in this position I have not seen it well, but repeatedly in the increase with $5\frac{1}{2}$ in. achrom. and $9\frac{1}{3}$ in. reflect., when the bank appears cut down before reaching the E. side: once I saw the S. of these lines, but cut off at its E. end; at another time the N., perhaps continuous, while a similar line diverged from the same point W.

to the NE. side of the crater. A bay at the N. end of **93**, shewn by L., but missed by B. and M., seems the result of a smaller explosion. This curious spot should be examined with the most powerful means. B. and M. describe and figure a wall to **93**; Schr., L., and myself (even with reflector) see none.* The cleft then, after touching on five very small craters and two broad hills, becomes wider and shallower, and ends after about 106 m. much as it began. S. of this cleft are two small dark spots, one larger, and one of a greenish hue: on the N. side is a region worthy of notice for its change of colour: in Full it is tolerably luminous: at Quadratures, there is near **93** a large blackish spot, covering two ranges of hills and the vale between. Here B. and M., most unprejudiced if not oppositely-prejudiced witnesses, admit a variation of colour not dependent merely on the angle of reflection, and possibly connected with changes like those of our seasons.

Cleft of Ariadæus. This, discovered like the preceding by Schr., lies W. of it; it is longer, broader, and probably deeper than its neighbour, with which, as I found, 1866, Apr. 21, it is connected by a branch N. of **102**. It seems to pass under the two mountains nearest its W. end, but others it cleaves visibly, though greatly narrowed by one lofty hill. The accurate L. saw it passing through them all, and traced it for 175 m. I have observed it interrupted, but not exactly as B. and M.: I find it also double for a short distance—two halves not in the same line, with overlapping ends. G. and Kunowsky alone have detected a minute prolongation of it far through G. This and the preceding cleft may be looked for about I. Quarter.

* Schm. thinks there are no lunar craters without banks. Such 'explosion-craters' exist, however, in Java the Eifel, and Auvergne.

TRIESNECKER (**94**) is surrounded by several minute clefts intersecting and uniting with each other in a manner of which only one other instance is known (near **228**; Schm.). L. missed them. With 5½ in. I found more than in B. and M.; one cleft double, with overlapping ends. Gaudibert has traced others.

MANILIUS (**95**), a beautiful cavity, 25 m. in diameter and 7,700 f. deep, has a broad luminous terraced crater- and peak-besprinkled ring. Being visible on the night-side, it was one of Herschel I.'s imaginary volcanos. Schr. has seen variations, not easily accounted for, in the relative visibility of this and **70** in the earth-shine.

JULIUS CÆSAR (**96**) and BOSCOVICH (**98**) are very dark hollows, DIONYSIUS (**99**) and SILBERSCHLAG (**101**) very brilliant crater-rings.

Near the two fine craters AGRIPPA (**102**) and GODIN (**103**) (which exemplify the remark under **84**), Schr. once saw for a short time on the dark side, a minute point of light.

RHÆTICUS (**104**), an irregular crater, marks exactly the Moon's Equator, and is one of the few spots to which the Sun and Earth may both be vertical. (See another Rhæticus, in a note on **112**.)

SECOND, OR NORTH-EAST QUADRANT.

SCHRŒTER (**106**). This imperfect crater in an intricate district where the levels are bright, the hills and valleys very dark grey, is the guide to a remarkable spot a little N., the number on the map standing between the two objects. Here, in 1822, G. discovered the regular formation which at first attracted so much attention, and subsequently, from the fanciful character of the observer, fell into unmerited oblivion.

The object, which he called Schröter (a name transferred by B. and M., when they could not find it, to the nearest crater), and which he maintained, notwithstanding its size, to be a work of art, is described by him as a collection of dark gigantic ramparts, visible only close to the terminator, extending about 23 m. either way, and arranged on each side of a principal meridional rampart in the centre, from which they slope off SE. and SW. respectively, at an angle of 45°, like the ribs of an alder-leaf; those to the SW. abutting on a meridional side-wall, beyond which Schwabe and himself subsequently perceived their continuation: frequently however traces only of the figure could be discerned, as though it were obscured by clouds; from this cause he supposed it had been quite misrepresented by the careful L., though he had studied it for six months: some years afterwards it appeared to have undergone a sudden change, and G. himself could scarcely make it out: B. and M., notwithstanding great pains, were quite unsuccessful, till in 1838, subsequently to the date of their map, they surveyed and measured the region with the great Berlin achromatic of $9\frac{6}{10}$ in. aperture; then at last, among a number of curious labyrinthine details, of which their 'Beiträge' contains a view, five parallel valleys appeared side by side, each about 9 m. by $3\frac{1}{2}$, sloping all to SW., with prolongations in the same direction, giving very fairly half of G.'s figure—a remarkable attestation from an unfavourable quarter. But he could call many earlier witnesses, having shewn it to several German philosophers; Prince Metternich too, at Vienna, found it from his description, and it was beautifully seen by Schm. and Schwabe. In England it does not seem to have been looked for, as though to justify G.'s taunt, 'The scientific John Bull here has gone empty away, and behaved himself about it just as his

natural disposition led him.' This is, however, no longer true. Knott saw it, 1861, March 19: I caught it with $5\frac{1}{2}$ in. 1862, Feb. 7, a long way from the terminator, which passed through **121**; and could even trace it the next day. I have several times seen it since, but never on, or near the terminator. It has been finely seen by Whitley, 1870, June 7 and 8; and somewhat differently by Birmingham, 1871, March 29. It is a curious specimen of parallelism, but so coarse as to carry upon the face of it its natural origin, and it can hardly be called a difficult object.* A line from **211**, through **106**, carried as far again, finds it a little N. of its place in the map.

SINUS ÆSTUUM (**N**). The absence of even the minutest crater here is remarked as unique: but L. had shewn one, and M. subsequently picked out a few with the Dorpat telescope. I have found two easy with $5\frac{1}{2}$ in.

ERATOSTHENES (**110**) and STADIUS (**111**), neighbours, the former more than 37 m. broad, the latter 5 m. broader, connected by a steep mountain of 4,500 f. (higher than any land in the British Isles), are curiously contrasted: **110** has a fine central hill, **111** is nearly level. **110** has a widely-terraced wall of very irregular height; the surrounding ground is also very uneven; so that on E. side it is 16,000 f. above the inner, 7,500 f. above the outer surface; on W. only 10,000 f. and 3,300 f. **111** has such an insignificant ring, about 130 f. high, that B. and M. did not notice it till after a three-years' search for *Riccioli's* Stadius, which, being only a spot of local colour, they missed after all.† I found, however, little difficulty with this ring. Its interior, as pointed out by Dobie, is

* Birt has referred to a similar formation in Auvergne, described by Scrope, 'Extinct Volcanoes of Central France,' 162. (2d edit.)

† See next note.

curiously speckled, especially S. and W., with minute craters. **110** is about as large as the county of Hereford, and lies intermediate between most dissimilar regions. Its Full-Moon aspect is very unlike the description of B. and M., and should be drawn and watched.

COPERNICUS (**112**). One of the grandest craters, 56 m. in diameter. It has a central mountain (2,400 f. Schm.), two of whose six heads are conspicuous; and a noble ring composed not only of terraces, but distinct heights separated by ravines: the summit, a narrow ridge, not quite circular, rises 11,000 f. above the bottom—the height of Etna, after which Hevel named it. Schm. gives it nearly 12,800 f. with a peak of 13,500 f. W., and an inclination in some few places of 60°. Piazzi Smyth observed remarkable resemblances between its interior conchoidal cliffs and those of the great crater of Teneriffe. A mass of ridges leans upon the wall, partly concentric, partly radiating; the latter are compared to lava, and the whole is beautifully though anonymously figured in Herschel II.'s 'Outlines of Astronomy.' There is also a large drawing by Secchi: but this grand object requires, and would well reward, still closer study. It comes into sight a day or two after I. Quarter. Vertical illumination brings out a singular cloud of white streaks related to it as a centre. It is then very brilliant, and the ring sometimes resembles a string of pearls: B. and M. once counted more than 50 specks.*

* On the SW. of **112** Hevel has figured three contiguous round dark spots under the name of 'Lacus Herculeus.' Of these the NW. was named by Riccioli 'Dominicus Maria,' the SW. 'Stadius,' and the E. 'Rhæticus.' B. and M., puzzled in identification, owing probably to their being *full-moon* markings (though easy ones), dealt summarily with this nomenclature; ignoring Dom. Maria, notwithstanding its claim of neighbourhood to the site **111**; transferring Stadius across it, withou

CRATER-RANGES NEAR COPERNICUS. Between **110** and **112** lies one of the most curious districts in the Moon. Here, in strange contrast with the undisturbed Sinus Æstuum, B. and M. have shewn 61 minute craters, believe that more than twice that number might be seen, and question whether any level ground is left. Schm. reckons about 300. The greater part are arranged in ranges; one row is very evident, where they stand so close that but for their partitions it would be a cleft, as indeed its N. end seems to be. The telescope at Dorpat shewed M., after his removal there, great part of the Hyginus cleft as a chain of confluent openings,* thus strengthening the idea that these forms may have had a common origin. This region, strangely missed by Schr., was discovered by G., who estimated its minute craters at 400 or 500 f. in diameter; B. and M. give them about six times that size. They are easily seen, but the suitable illumination is fugitive: they should be looked for while the Sun is rising on E. side of the wall of **112**.

TOBIAS MAYER (**117**), 9,700 f. deep towards W., has a fine specimen of subsequent eruption by its side.

MILICHIUS (**118**). Remarkably luminous in Full.

MARE IMBRIUM (**O**). The largest of the circular plains, ill-

any intimation, *per saltum*, to that position; and removing Rhæticus to **104**, at some distance. The latter transposition led to a mistake in the first edition, which Knott has enabled me to rectify. It is this original Rhæticus, not **104**, in which G. discovered one of his curious 'rampart-works;' and I should have given a copy of his figure in Astr. Jahrb. 1828, had he not himself condemned it. It was something like his 'Schröter,' a slightly curved line, with a little crater at one end, and a mound at the other, crossed by four shorter straight lines. A year later he complained that it had been greatly obscured 'selenospherically,' and seldom visible.

* W. of **93** I have, however, seen its bottom apparently quite flat under high illumination, with Bird's 12 in. silvered reflector.

defined E., five times as large as M. Crisium: one half dark and flat, the rest very irregular.

ARCHIMEDES (**120**). One of the most regular walled plains, apparently more ancient than the surrounding level, which seems to have nearly filled up its interior, and overflowed the lowest slope of its ring: though 60 m. in diameter, it is depressed only about 650 f.; the wall, averaging 4,200 f. above the interior, carries several towers, the highest nearly 7,400 f. The plain appears smooth as a mirror, but is divided into 7 nearly parallel stripes of unequal brightness. There are minute craters in it: G. saw one, Knott 6 or 7. The outer slope of the wall is very complex; a magnificent object against the rising or setting sun.

LA HIRE (**123**), a small solitary mountain, inserted in the map of B. and M., and in the index of their 'Mond,' but strangely omitted in the text. There is nothing striking in its usual appearance, but it was twice seen by Schr. under very different illumination, so brilliant as to glitter with rays like a star: he noticed also changes in its form. G. never saw its radiant aspect, and thought its shape entirely altered, and its size reduced, since Schr.'s time. I once found it on the terminator, $2^d\ 7^h$ after I. Quarter, the brightest object in sight, and radiating as described by Schr. At another time I noticed a similar hill, about $\frac{1}{3}$ of the distance from **122** to **121**, glittering on the terminator like a star with rays.* Gerling found the same phænomenon in a peaked hill on S. side of **80**, 1844; and Brodie close to **149**, 1865. I have also seen **131**, and a hill S. of it, very brilliant in the like circumstances. Future observation may decide whether this depends upon a peculiar

* This has also been seen by Hunt, 1862.

angle of reflection and vision, or on some changes in a lunar atmosphere. **123** is, according to Schr., about 4,900 f. high.

EULER (**125**), 19 m. across and nearly 6,000 f. deep, is conspicuous for its bright streaks.

CARLINI (**128**). In this neighbourhood Williams and two others observed for $1\frac{1}{2}$ h., 1865, Nov. 24, on the dark side, a distinct bright speck like an 8 mag. star with $4\frac{1}{16}$ in. aperture. This region should be mapped with special care.

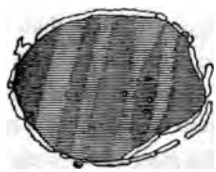
HELICON (**129**) and its neighbour Helicon A (now LE VERRIER, **425**) form a curious twin crater, each 13 m. in diameter, and of vast depth. Schr. has given the latter of them 13,600 f.; its complete disappearance in Full,* while **129** remains conspicuous, is a striking instance of this peculiarity, and may account for the entire omission of one of them in the maps of Hevel and Riccioli. Did two small craters, on the wall of **129** and the slope of **425**, exist in B. and M.'s time? They are plainer than another which they have given here. I have seen with 9 in. a central crater in **129**,—a test-object.

PICO (**131**) is a very fine specimen of an insulated pyramid, rising from a narrow base to 9,600 f. according to Schr., reduced by B. and M. to 7,000 f. (nearer 8,000, Schm.): on any estimate a magnificent sight from the surrounding plain: Schm. however thinks the profile would not be very striking, quite inferior to the steeper of the Swiss Alps, or even the Niesen above the Lake of Thun.

PLATO (**132**). A slight magnifier shews this 'steel-grey' spot, lying as a lagoon at the edge of **O**, and fore-shortened into an oval, whose proportions vary from (3 to 5) to (4 to 5) in the extremes of N. or S. libration, its distance from the N. limb being in the one case half of its amount in the other:

* Brodie finds (1865) that this is incorrect.

such optical variations must always be allowed for in making or comparing delineations of objects not far from the limb. The rampart, not a very connected one, averages 3,800 f. E., something less W., where three towers crown it, the loftiest nearly 7,300 f., another somewhat higher bulwark surmounting the E. side (Schm. gives 9,000 f.). The very level interior, about 60 m. broad, and containing 2,700 square miles, was crossed, according to B. and M., by four lighter streaks from N. to S., and contains many specks, which rank among the minutest of lunar objects. The central one is not difficult under a high light, and, with several others, is evidently a 'craterlet.' Two are quite close, like a double star (Dawes). G. detected 8. 4 are shewn by B. and M., a copy from whose map is given here,* as the local shading, considered very variable by G., was found greatly changed by me, 1855, and is so still. Elger has seen, 1871, some longitudinal bright streaks at lunar sunrise. The light-specks



have been of late very carefully studied by many observers. 37 have been recorded (27 the greatest, 8 the average number at once), as well as about 20 streaks; and Birt's most accurate comparison of the whole series shews that the visibility of many of them is affected at times by some local cause. There is a large landslip at SE. end of ring.

Harpalus (**133**) has a wall rising 2,800 f. above the plain, nearly 16,000 f. above the chasm below.

Sinus Iridum (**P**), styled by B. and M. 'perhaps the most magnificent of all lunar landscapes,' is a dark semicircular bay, level almost as water, and encompassed by abrupt and colossal

* These streaks have been omitted in the 2d edition.

cliffs, the promontories being upwards of 140 m. apart. The ridge is crowded full of minute, usually round summits, with numberless other objects: the height is not conveniently measurable, but a point W. of SHARP (**139**) reaches about 15,000 f. Between it and **132** is a strong NW. parallelism. **P** is in noble projection 2^d or 3^d after I. Quarter.

KEPLER (**144**), nearly 22 m. in diameter, sinks 10,000 f. in the deepest part beneath a very low bright wall. It is the centre of a great ray-system, connected with that of **112**.

MARIUS (**147**). The interior of this cavity is both drawn and described by B. and M. as quite uniform. It now contains a *minute white crater*, conspicuous in the lunar morning, though invisible in the evening. There is also a trace of some other object. A similar crater E. of the ring is not in Schr.'s figure. More than 100 grey hillocks, the loftiest little exceeding 1,000 f., lie in a narrow space NE.

ARISTARCHUS (**148**). The most brilliant crater in the Moon; quite dazzling in a large telescope, the steep central hill being the most vivid part. The ring is 28 m. across, on W. rising 7,500 f. above its inner, 2,650 f. above its outer foot: on its inner N. slope G. has seen two vertical dykes as of trap (I have remarked something of the kind in **124**): on E. it becomes a plateau, which connects it with a smaller and steeper crater, HERODOTUS (**149**). A curious serpentine valley will be noticed here, nowhere exceeding $2\frac{1}{2}$ m. in width (about $\frac{1}{3}$ m. deep, Schm.), not unlike a dry river-bed. The reflective power of **148** is extraordinary, rendering it visible even to the naked eye on the bright side, and with the telescope on the dark: one of Herschel I.'s very few errors was his taking it for a volcano in eruption. Schr. pointed out this, but the mistake has been since repeated by others. There are however, as

already mentioned, variations in its light, noticed by Schr., for which Smyth, who has seen it of every size, from a 6 to a 10 mag. star, says it is difficult to account.* The bright streaks around it in Full Moon are no more of the nature of lava than they are elsewhere; but I have seen it on the terminator surrounded by wavy radiating streams. About 45 m. WNW. begins a little group of mountains (**490**), the highest nearly 6,300 f.: these coming into light about 3^d after I. Quarter are the 'harbingers' of the great spot, conspicuous a day later. Birt remarks that **489**, a mere ring in the map of B. and M., wears a very different aspect now.

Hevel (**154**), a walled plain 70 m. across, contains a straight ridge, and an extensive convexity of surface; also a small crater, considered by Schr., but on inadequate ground, to be new.

Anaxagoras (**168**), 31 m. broad, and very white, includes a great mountain not in the middle. It is a streak-centre.

Between Timæus (**170**) and Fontenelle (**171**) is a good deal of parallelism, and adjoining **171** on W. is one of the most curious instances of it: a nearly square enclosure foreshortened into a lozenge, whose rampart-like boundaries, according to B. and M., 'throw the observer into the highest astonishment.' They are very unequal in height, and one is only a light-streak, yet they are so regular that it is scarcely possible to imagine them natural, till we find that they are 64 m. long, 250 to 3,200 f. high, and 1 m. or more thick. There are parallel ridges in the interior, and in one place the form of a perfect cross: unfortunately, it lies in such a position that years, as B. and M. observe, may pass without a good view of it. I have often looked for it in vain. Birmingham has been more successful.

* See p. 70, note †.

E. of the table-land ROBINSON (**413**), are three curious *dark* mountains, about 5,900 f. high.

PYTHAGORAS (**176**) is the deepest walled plain in the Quadrant, nearly 17,000 f. on SE. side.

THIRD, OR SOUTH-EAST QUADRANT.

THIS includes the metropolitan crater of the Moon, TYCHO (**180**), a most perfect specimen of the lunar volcano, visible even to the naked eye in Full, and roughly figured by Galileo in the earliest telescopic representations. Its diameter is 54 m., its depth 16,600 f. or nearly 3 m., so that the summit of our Mont Blanc would drop beneath the ring: the height of its fine central hill 5,000 f.* (6,000 Schm.), ranging nearly with the terraces, from three to five rows of which border the inner slope of the narrow wall. This noble object lies among so many competitors that it is not always immediately identified by an unpractised eye near the terminator, a day or two after I. Quarter; but as the Sun rises higher upon it, its preeminence becomes more and more evident. Its vicinity is thronged with hillocks and small craters, so that for a long distance not the smallest level spot can be found; further off, the craters increase, till the whole surface resembles a colossal honeycomb. At **180** commences the largest of the systems of rays, extending over fully one-fourth of the visible hemisphere, one ray passing through **H**, almost to the opposite limb. Everywhere the

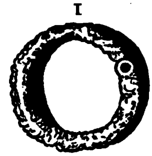
* A smaller hill close to it on the W. is omitted by B. and M., though readily seen. Birt rediscovered it, but it appears in L.'s map. Gaudibert has detected a most curious cleft passing along the inner NE. slope, crossing the crest, and running down the outer SE. face of the wall with a branch inside, and another outside the rampart.

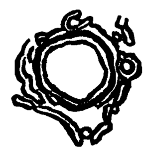
visibility of the streaks is the converse of that of the shadows, so that many great ring-mountains which are overspread by these rays, become totally imperceptible under high illumination. They have no connection whatever with the form of the surface, are not in the least elevated or depressed, and resemble nothing on the Earth. In Full the central hill and wall of **180** are brilliant, the interior dark, as well as an exterior zone, beyond which a light cloud forms the base of the streaks. Their appearance reminds me of a vast net gathered up round a circular opening.

HESIODUS (**187**) guides the eye to a cleft E. of it, in the M. NUBIUM (**S**).

CICHUS (**189**), a crater in table-land, lies 9,000 f. beneath the plateau, 4,000 f. below the plain: its ring bears a smaller crater—an object of some interest. In 1833 I perceived that it was twice as large as it had been represented three several times by Schr. On becoming possessed of the map of B. and M., I found it there also enlarged. Schr., though a clumsy, was a faithful draughtsman; his views have the appearance of being each independently drawn, and they are under different angles of illumination, which often vary the apparent size of small craters; so that here may be a *suspicion of volcanic action since* 1792: the characteristic silence of B. and M. may be disregarded. The two figures here given, of which 1 is a copy of Schr.'s design, 1792, Jan. 4, and 2 is taken from B. and M.'s map, may serve as specimens of the respective modes of delineation adopted by these observers.

1





2

LONGOMONTANUS (**192**). A great ring, 90 m. across, very

deep: a peak on W. wall measures nearly 15,000 f. The region is most wild and dislocated. **192**, with Heinsius (**190**), a triangle of craters each highest W., as is common here,—and Wilhelm I. (**191**), are admitted by B. and M. to be a little misplaced and out of proportion in their map.

Clavius (**193**). One of the grandest cavities in the Moon, though ill-placed for observation; tolerably circular, and more than 142 m. broad; it is encompassed by a wall damaged by successive explosions, but still portentously high and steep, attaining 17,000 f. in one of its W. peaks, and covering the gulf with night amid surrounding day. On and within the ring Schm. counts at least 90 craters. 'In a good telescope,' we are told by B. and M., 'the prospect of a sunrise upon the surface of Clavius is indescribably magnificent.' The shaded side, they justly remark, cannot be in perfect darkness when exposed to the reflection of such an enormous mass of enlightened cliffs. The bottom of the small included crater lying furthest W. falls 23,000 f. below the peak already mentioned —an interval greater than the height of Chimborazo. Well may these observers express their astonishment that of this gigantic bulwark not a trace can be discovered in the Full Moon! About 1^d after I. Quarter, Schr. remarks that its shadow blunts the S. horn to the naked eye.

Maginus (**195**). The ruin of a vast complex ring, with an interior depressed 14,000 f. Some minute hillocks and a little hollow in its centre form a good test. The Sun rises grandly upon it a little after I. Quarter, but 'the Full Moon knows no Maginus!' S. of its W. side lies a hollow, the only dark spot under high lights in all this wild region.

Saussure (**196**) interrupts one of the streaks of **180**—a

solitary instance in so large a ring. W. of it the surface swarms with little craters, some hardly 0″5 in diameter.

NASIREDDIN (**198**) and Nasireddin a, just N., are two fine craters; the latter reaches 11,000 f. The former I have often wondered at, about I. Quarter, as the culminating point of immense explosive energy.

The GREAT CRATER-RANGE of the 1st Meridian comprises 5 vast walled plains in almost uninterrupted succession, which, like two other series near each limb, seem to have been formed upon a long cleft running N. and S.: similar volcanic phænomena occur on the Earth—for example, the Andes, and the Puys of Auvergne. The 5 lunar circles greatly resemble each other in character. We begin at the S. end:

1. WALTER (**200**) has lofty peaks on its rampart.

2. PURBACH (**202**) is about 7,500 f. deep. NE. of it, out of the main line, lies

THEBIT (**203**) 32 m. broad, 9,800 f. below one part of its ring. The wall has been pierced by a smaller and deeper crater, against the ring of which a yet lesser mine has been sprung. E. of it we find the

STRAIGHT WALL, a most curious formation, regular enough for a work of art, but more than 60 m. long, and of a very uniform height of 1,000 f.; (880, Schm.). To me it appears brownish. At one end is a small crater; at the other a branching mountain, giving it, as B. and M. say, the appearance of a staff tipped with a stag's horn. It may be well seen from 1d to 2d after I. Quarter. We now return to the centre of our series:

3. ARZACHEL (**204**), 65 m. across. On W. side of ring is a peak of 13,600 f. Its neighbour,

ALPETRAGIUS (**205**), is so deep—on W. 12,000 f.—as to be only five or six days free from shadow. E. of it is a very brilliant little crater, Alpetragius B.

4. ALPHONSUS (**207**), 83 m. in diam., has a steep central peak of 3,900 f. (4,500, Schm.), about the height of Vesuvius; under a high light two bright specks, and several defined blackish patches, vary the surface, in those places perfectly level. Schm. sees 2 clefts in both **207** and **204**.

5. PTOLEMÆUS (**208**) is the last and largest of the chain: its breadth (over-stated by Schr.) is 115 m.—a magnificent lake, whose surface at sunrise or sunset is occasionally seen all roughened with ridges like waves, not 100 f. high. I have seen the shadows of the W. mountains in it drawn out into bundles of black filaments. Schm. gives part of its boundary 12,800 f., and counted, with the Berlin achromatic, at least 46 little craters in its interior; 12 in E. forming a chain.

MŒSTING (**211**) has a vast depth of 7,500 f. beneath a wall only 1,600 f. high on the outside. A minute crater S., Mösting A, is very luminous. HERSCHEL (**212**), 9,500 f. deep, forms with **211** and **94** a triangle marking the Moon's centre.

BULLIALDUS (**213**), a grand crater, 38 m. across, 9,000 f. deep, with a quadruple central hill of 3,200 f., is connected by a gorge with a little crater, and is the centre of a remarkable group. I have seen a large radiation round it, as of ejected matter. SW. of it Whitley has discovered several minute crater-chains.

EUCLIDES (**221**) is the best specimen of an infrequent variety, the 'light-surrounded' crater. There are nine of these—all deep, regular, not large, bright, and encompassed immediately by a luminous cloud not resembling the white streaks in character. Four of them lie near

LANDSBERG (**222**), whose ring of 28 m., with a greatest height of 9,700 f., must command a boundless prospect over the dead level W. of it: it rises very gradually without, but is steep and terraced within.

FLAMSTEED (**223**) is a crater combined with a circle of banks averaging only 320 f. in height, which is complete in Full, and looks like an overflowed ring.

MARE HUMORUM (**T**) is a small circular foreshortened plain, about 280 m. across, which may be detected by a keen unaided sight. The greater part is as distinctly green as **H**, with, in most parts, a narrow grey border.

CAMPANUS (**226**) contains a remarkably dark centre, and two minute craters not in B. and M.; E. of it lie four little clefts, I have seen three readily, 2^d 3^h after I. Quarter.

VITELLO (**229**) is unparalleled for having, within a second concentric rampart, a central peak overlooking the whole ring.

GASSENDI (**232**), a conspicuous walled plain, 55 m. across, lies considerably higher than the M. Humorum. Its loftiest point is 9,600 f. above the interior, which contains many minute objects: one little hill shines brilliantly in Full. Schr. noticed several changes here: and there is a strange diversity in the drawings by different hands: it still requires careful study and delineation. It must be remembered that its proportions vary considerably according to libration. Several curious clefts may be at times made out in it. Schm. mentions at least 14.

MERSENIUS (**231**) has a convex interior, with several minute craters, hills, and clefts; L. gives but one craterlet; B. and M. omit everything: Schm.'s drawing is unsatisfactory. This should be well studied. Two little craters, Mersenius B (NE.)

and c (NW.) are very luminous. Between **231** and **232** are two clefts, seen plainly by me 4^d 3^h after I. Quarter.

HAINZEL (**237**) is of great depth and steepness: the ring of CAPUANUS (**238**) is peculiarly irregular in height.

SCHICKARD (**239**), an enormous plain, exhibiting a fine scene between 4 and 5^d after I. Quarter, is encircled by a complex wall, 460 m. in circuit. Chacornac observes, that from the rapid rounding of the lunar globe, a spectator in the centre would think himself in a boundless desert; the ring, though in the N. more than 10,500 f. high, being invisible in every direction. The interior is nearly level, but its colour strongly varied—a curious contrast to the monotony of its neighbour, PHOCYLIDES (**242**). The latter I have frequently seen crossed by a grand shadow from a peak in the ring.

WARGENTIN (**243**) is a singular formation; a circular elevated plain 54 m. across, which, excepting for a very slight rampart, resembles a large thin cheese.

BAILLY (**245**), like a small sea, lies near the limb; its wall, probably almost as high as that of **193**, seems to run back into the

DŒRFEL MOUNTAINS (**246**), a region of enormous elevation, whose summits are occasionally visible in grand profile. B. and M. admit that Schr. did not over-estimate them at 25,000 or 26,000 f.

Great craters lie between **242** and S. pole. KIRCHER (**252**) is 18,000 f. deep, among numberless small explosions. CASATUS (**254**) is still deeper; a dome upon its mighty wall rises to about 22,300 f. KLAPROTH (**255**) is a wonder of flatness in these regions.

NEWTON* (**256**), an irregular crater, 142 m. long and about

* B. and M. transferred this name from a spot so called by Schr. in **O** close to **132**, which they thought unworthy of the designation. There

half as broad, is the deepest hitherto known: the height of its loftiest tower is probably about 23,900 f. above the interior.

A colossal mountain range breaks up the limb here, fully rivalling **246**, and far exceeding anything within the disc: it extends along a considerable arc of the 3rd and 4th Quadrants. In the crescent its summits frequently prolong the horn; in Full, with suitable libration, they come out in striking projection on the sky,* while even their apparent bases may lie far above any lunar 'sea.' Their outline is rather rounded: some long ridges may be the profile of great rings. I find a clear description and rough measure of them by Cassini, in 1724. Schr., who did not know of this, observed them more correctly, and named them the LEIBNITZ MOUNTAINS (**259**). The E. extremity ranges with the bright streak running S. from **180**. By some unwonted inadvertency, B. and M. have interchanged the names of **246** and **259**.† I have preferred retaining them as given by the earlier discoverer. These and other ranges sometimes roughen the limb during a solar eclipse, but Schr. found that their peaks then appear much sharper from the irradiation of the Sun.

BLANCANUS (**260**), a noble crater, 51 m. in diameter, with a terraced and turreted ring, domineers 'like Etna over Sicily,' bearing a peak of 18,000 f. above the interior.

SCHEINER (**261**), larger and steeper, includes 10 craters and a partition.

was some inducement in this instance; but the precedent should not be followed, as liable to produce confusion.

* We never see a *real* Full Moon; that is, she is never exactly opposite to the Sun except when centrally eclipsed; hence there is always a small deficiency at one or the other pole; and libration must be favourable, to shew these mountains well, and *on a circular limb.*

† Yet they complain without cause that Schr. is not explicit here. They must have been but superficially acquainted with his work.

MORETUS (**262**), a very fine object, is 78 m. broad, but of unequal height, 15,000 f. on W. side, widely terraced within, with a bright central hill, the loftiest yet measured,—6,800 f., by which it is easily identified. Its sunrise or sunset are very fine: it may be seen in noble relief about 1[d] after I. Quarter.

GRUEMBERGER (**265**) has a central crater, whose bottom is probably more than 20,000 f. below a great peak in the wall.

ZUPUS (**268**). A valley, very dark in Full. SIRSALIS (**270**), a double ring.

GRIMALDI (**272**). The S. link of a chain of great craters lying in the meridian. This grand spot, 147 m. long by 129 wide, has a darker interior than any portion of the Moon of equal size; it has sometimes been detected even without a telescope. G. perceived here a regular formation somewhat resembling the letter *H* much inclined.

RICCIOLI (**273**) is in part as dark; its ring is grand before the rising or setting Sun.

The CORDILLERAS (**274**) and D'ALEMBERT MOUNTAINS (**275**), a series of great ranges, nearly 20,000 f. in general height,—much higher, according to Schröter, in parts—rise along the E. limb. They extend far S., and this extremity is called the ROOK MOUNTAINS (**276**). Two valleys were discovered by Schr. in profile on this limb, of enormous depth, rivalling the height of the mountains.

BYRGIUS (**279**) has on its ring a small crater, Byrgius A, remarkably brilliant, and a centre of streaks. NE. of it stands a great mountain, of probably at least 13,000 f.—as high as the Swiss Jungfrau.

FOURTH, OR SOUTH-WEST QUADRANT.

HIPPARCHUS (**288**), 92 m. across, contains all kinds of formations. Schr. has seen the shadow in its interior bordered on SW. by a fringe of fine lines, indicating a row of sharp and regular pinnacles on the wall. Three small craters, Hipparchus E, G, and C (reckoned towards S.), in and near W. wall, are very bright in Full.

ALBATEGNIUS (**289**). A walled plain, 64 m. wide, very level. Its rampart, 14 to 18 m. broad, has been all torn by explosions; B. and M. counted at least 33 of their results: a peak in NE. attains 15,000 f. Its central hill, piercing a mass of shade, forms a noble spectacle, which I have seen 10^{h} before I. Quarter.

Craters with irregular walls and very large central mountains bend round from **289** through AIRY (**291**), to LA CAILLE (**292**). This last, with a wall of 9,700 f., is quite level.

WERNER (**295**) is one of the loftiest rings; its narrow ridge ranging 13,000 f. (the height of the Alpine Eiger) above the depth, and rising on the E. to 16,500 f., nearly 1,000 f. loftier than our Mont Blanc. A spot on the SE. side of it is very bright—another, on the inner slope of the NE. wall, is stated to be as brilliant as **148**, and more luminous than any other part of the Moon; but this 'star-like flashing point,' being only between 4 and 5 m. square, is said to be easily overlooked with low powers. I have several times readily seen it with two achromatics of $3\frac{7}{10}$ in., and powers 75, 80, and 144, but *never of the specified brilliancy*: and a careful study of it in 1864, with $5\frac{1}{2}$ in., confirmed with a 9 in. mirror in 1871, induces me to believe that *it has faded since the date of*

B. and M. The reflector has shewn in it a minute black pit and very narrow ravine.

ALIACENSIS (**296**) is similar to **295**, but larger.

THEON SEN. (**297**), THEON JUN. (**298**), ALFRAGANUS (**300**), are all luminous.

ABULFEDA (**305**) and ALMANON (**306**) have their walls united by a row of little craters like a cleft, visible about I. Quarter.

ABENEZRA (**310**) sinks more than 14,500 f. PONS (**313**) has very dark spots in the ring.

ALTAI MOUNTAINS (**315**). This long range (name omitted in B. and M.'s map) is almost the only undisturbed high ground in this Quadrant. Its rounded summits lie awkwardly for measurement, but seem about 13,000 f. I have often seen the NW. face as a bright line of nearly 280 m. of cliffs, in the increasing Moon.

A group of three huge craters follows, forming a wild and gigantic region, very difficult to delineate. The details occupied B. and M. portions of more than fifty nights. It has since been effectively sketched by Phillips.

THEOPHILUS (**319**) is the deepest of all visible craters, if we regard the general line of the ring, which ranges from 14,000 to 18,000 f. above the chasm, with a diameter of 64 m. No scene in the least approaching to it exists on the Earth. The central peak is 5,200 f. high (more than 6,400, Schm., who gives the wall but 3,200 f. outside height, and finds it surrounded by radiating ridges: these I have seen with a 9⅓ in. silvered speculum). CYRILLUS (**320**), equally large and terraced, approaches to a square. A small crater, Cyrillus A, on its E. side, is very brilliant. CATHARINA (**321**) is rather the largest of the three, and more than 16,000 f. deep, but irre-

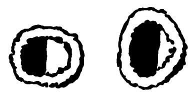
gular in character. Of this superb cluster, **319** first catches the rising Sun, and I have seen it far beyond the terminator, and even without the telescope, 5^d after New: it is a grand object when filled with night, through which its glittering central peak comes out like a star. A wide valley connecting **320** and **321** is much better represented in the beautiful old map of Tobias Mayer, and by Russell, than by B. and M.

Isidorus (**323**) and Capella (**324**) lie side by side, with a peak of more than 13,000 f. between them; three clefts cut down the ring of **324**. Schr. here saw traces of a line of little confluent craters. Double craters, too numerous not to have some special cause, abound in this region.

Censorinus (**325**), a minute crater, with its vicinity, is very brilliant in Full.

Messier (**327**) and Messier a, a pair of small deep craters, exhibited in the time of B. and M. such a curious similarity in size, form, depth, brightness, and even the position of the peaks upon their rings, that it must have been either a wonderful coincidence, or the result of some unknown natural process. This similarity no longer exists, and we have here strong evidence of *modern physical change.* Two curious white streaks, slightly divergent, extend from Messier a for a long distance E., forming with the included shade the picture of a comet's tail. G., who imagined them to be artificial, states that they are composed of a multitude of distinct parallel lines. In consequence of an observation by Schr., who discovered this 'comet,' B. and M. fortunately examined this spot, so peculiarly calculated to exhibit any variation, *more than* 300 *times*, between 1829 and 1837, without noticing any change. 1855, Nov. 14, I perceived with my $3\frac{7}{10}$ in. achrom. that the E. crater appeared the larger of the two. 1856, March 11, I

found the W. crater not only the lesser, but '*lengthened obviously in an E. and W. direction.*' I have since noted the dissimilarity with larger instruments, and it is in fact matter of very easy observation. The figure is taken from a rough sketch, 1857, Feb. 28: the shadow is probably too broad in W. crater, which is that to the left in the inverted diagram.



GUTTEMBERG (**330**), like many of its neighbours, is pear-shaped. E. and S. of it lie the

PYRENEES* (**331**), two mountain masses, the N. portion 12,000 f. high.

BORDA (**337**) has a lofty range on its W. side; a peak (Borda *a*) lying in the direction of the centre of **340**, rises at one spring 11,000 f., as abrupt as the Alpine Wetterhorn, or the two great Pics du Midi in the terrestrial Pyrenees.

We come now to the last of the three great rows of craters lying in the meridian, consisting of the four following objects, which must be looked for in the crescent 3^{d} or 4^{d} old, or at a shorter interval after Full:—

1. LANGRENUS (**338**) is a superb object under oblique sunshine, with its multiple ring 9,600 f. high, raised in SE. to more than 15,000 f. by Schm., who gives 5,800 f. to its brilliant central hill.

2. VENDELINUS (**339**) is unequal to **338**, though on the Earth it would be esteemed a wonder of magnificence; it contains a very dark speck in Full.

* This name is omitted in the 'Mappa Selenographica.'

3. PETAVIUS (**340**) is one of the finest spots in the Moon: its grand double rampart, on E. side nearly 11,000 f. high, its terraces, and convex interior with a central hill and cleft, compose a magnificent landscape in the lunar morning or evening, entirely vanishing beneath a Sun risen but half-way to the meridian. This, as well as **338**, is according to Schm. a centre of radiating ridges.

4. FURNERIUS (**345**) has a central crater, N. of which I have seen with $5\frac{1}{2}$ in. a bent cleft: the deep little crater Furnerius A at N. end of the wall is, in Full, a brilliant point on a white streak, and with another streak E. of STEVINUS (**344**) identifies this neighbourhood.

(NW. of KÆSTNER (**347**), in favourable libration, a large grey plain comes out from the limb, resembling **A**, and little, if at all, inferior to it in size. It was discovered, drawn, and described by Schr., and named by him Kästner, but strangely overlooked by B. and M., who appropriated his name to a ring (**347**) connected with it. This interesting region has received from the late Dr. Lee the appropriate name of MARE SMYTHII (**424**), in remembrance of one whose services to astronomy would, however, under no circumstances be forgotten. Its position in mean libration is shewn by a shaded space on the limb opposite **W** on the Map.)

(In various parts of the W. limb [I think from 6° to 9°, and from $11\frac{1}{2}$° to $18\frac{1}{2}$° S. lat., and on each side of 52° N. lat.—towards E. for 10°], very remarkable flattenings are visible in certain states of libration. Those to the S. lie behind **347** and **424**. They had been in part previously known to Dawes, but were first described by Key, 1863, Sep. 21. Their most striking appearance is very transient.)

WILHELM HUMBOLDT (**352**), one of several huge rings on the limb, shews peaks of 16,000 f. in profile.*

STŒFLER (**354**), rising in one part to 12,000 f., has a very level interior, crossed by two of the rays from **180**. It is well seen about I. Quarter.

MAUROLYCUS (**358**). A noble walled plain, sure to be found in grand relief about I. Quarter, or 2^{d} before III. Quarter. Its complex rampart is heaved up on E. side to 13,800 f.; on W., though not according to B. and M. quite so lofty, I have often seen it more conspicuous in the increasing Moon; and Schm. gives it here 18,000 f. B. and M. describe the plain as crossed by 12 diverging bright lines in Full.

BACON (**360**) has a peak on E. ring nearly as high as **358**, and on the top of SE. side a row of 5 minute craters.

LINDENAU (**370**), a perfect ring, rises on E. by four stages.

PICCOLOMINI (**371**), a noble circle 57 m. in diameter, has a central hill and complex wall, bearing on E. a tower about the height of our Mont Blanc.

FRACASTORIUS (**372**), a partially destroyed ring, which has been seen complete by Birt, forms a bay of the MARE NECTARIS (**V**): a little crater on E. headland is brilliant in Full.

From W. side of REICHENBACH (**375**) towards RHEITA (**376**) extends one of the gigantic valleys peculiar to this region. **376** has a ring reaching 14,000 f. Close under it, on the side next METIUS (**384**) is another valley 186 m. long, and from 14 to 23 m. wide, bordered by steep walls; in one spot more than 9,000 f. deep. Along W. side of FRAUENHOFER (**377**) is

* The smaller ring contiguous to its E. side was wrongly numbered **352** in the first edition of the map. This has been called PHILLIPS in the extended nomenclature, with the number **423**.

another valley 7 m. wide, which may be traced through **345**, though of very unequal depth, for 212 m.

STEINHEIL (**385**) is probably the deepest of the double rings, in one place sinking to 12,000 f.

VLACQ (**388**), the leader of a colossal group, is 57 m. across.

A little crater E. of NICOLAI (**393**) called Nicolai A, is very bright in Full. Minute insulated craters abound here at the rate of 65,000 for the visible hemisphere.

ZACH (**396**), 13,000 f. deep, is magnificently terraced.

CURTIUS (**404**) has a very complex and steep wall, probably surpassing the elevation of our Chimborazo.

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211. Mösting
212. Herschel
213. Bullialdus
214. Kies
215. Guerikó
216. Lubiniezky
217. Parry
218. Bonpland
219. Fra Mauro
220. Riphæan Mts.
221. Euclides
222. Landsberg
223. Flamsteed
224. Letronne
225. Hippalus
226. Campanus
227. Mercator
228. Ramsden
229. Vitello
230. Doppelmayer
231. Mersenius
232. Gassendi
233. Agatharchides
234. Schiller
235. Bayer
236. Rost
237. Hainzel
238. Capuanus
239. Schickard
240. Drebbel
241. Lehmann
242. Phocylides
243. Wargentin
244. Inghirami
245. Bailly
246. Dörfel Mts.
247. Hausen
248. Segner
249. Weigel
250. Zuchius
251. Bettinus
252. Kircher
253. Wilson
254. Casatus
255. Klaproth
256. Newton
257. Cabeus
258. Malapert
259. Leibnitz Mts.
260. Blancanus
261. Scheiner
262. Moretus
263. Short
264. Cysatus
265. Gruemberger
266. Billy
267. Hansteen
268. Zupus
269. Fontana
270. Sirsalis
271. Damoiseau
272. Grimaldi
273. Riccioli
274. Cordilleras
275. D'Alembert Mts.
276. Rook Mts.
277. Rocca
278. Crüger
279. Byrgius
280. Eichstädt
281. Lagrange
282. Piazzi
283. Bouvard
284. Vieta
285. Fourier
286. Cavendish
287. Réaumur
288. Hipparchus
289. Albategnius
290. Parrot
291. Airy
292. La Caille
293. Playfair
294. Apianus
295. Werner
296. Aliacensis
297. Theon, sen.
298. Theon, jun.
299. Taylor
300. Alfraganus
301. Delambre
302. Kant
303. Dollond
304. Descartes
305. Abulfeda
306. Almanon
307. Tacitus
308. Geber
309. Azophi

429. Struve, Otto
430. Mitchell, Miss
431. Somerville, Mrs.
432. Sheepshanks, Miss
433. Ward, Mrs.
434. De la Rue
435. Challis
436. Main
437. Adams
438. Jackson-Gwilt, Mrs.
439. Bond, G. P.
440. Maury
441. Maclear
442. Dawes
443. Cayley
444. Whewell
445. De Morgan
446. } Beer and Mädler
447. }
448. Terra Photographica
449. Pollock
450. Promontorium Lavinium
451. Promontorium Olivium
452. Promontorium Archidæum
453. Straight Range
454. Chacornac
455. Gwilt, G.
456. Gwilt, J.
457. Hind
458. Halley
459. Faraday
460. Horrox
461. Huggins
462. Miller
463. Birmingham
464. Ball
465. Bond, W. C.
466. Mädler
467. Argelander
468. Blanchinus
469. Delaunay
470. Faye
471. Donati
472. Alexander
473. Janssen
474. Cassini, J. J.
475. Foucault
476. Lee
477. Piton
478. Herschel, Miss
479. Brayley
480. Lockyer
481. Daniell
482. Grove
483. Murchison
484. Lassell
485. Hermann
486. Manners
487. Schmidt
488. Secchi
489. Schiaparelli
490. Harbinger Mts.

ALPHABETICAL TABLE OF LUNAR NOMENCLATURE.

MARS.

THIS planet, only about twice the size of the Moon, and not much more than half as large as our own globe, is yet peculiarly interesting to us, as presenting the most intelligible features of any object within our reach. In overtaking him about once in two years we find, as he turns to us his round sunny face, that his supposed malignant aspect is changed into that of a miniature Earth, which we might, without much extravagance, imagine to be habitable by man. Not every *opposition*, however, as it is called, admits of an equally near prospect. The orbits of both the Earth and Mars are elliptical, and not fixed with respect to each other, and no two following oppositions happen in the same part of either orbit, so that the most favourable possible juncture, when the Earth is furthest

from the Sun and Mars nearest, occurs ordinarily but once in 15 years, when the diameter of Mars, only 13″ in reversed circumstances, expands to 23″·5. Every opposition, however, should set the telescope to work; and we will proceed to describe what we may expect to see.

1. The *Phases*. These are not remarkable: in opposition, a full moon rising through ruddy haze, and, with sufficient power, larger than our Moon to the naked eye: in other situations a dull gibbosity, never sinking to quadrature. M. stated at one time that this phasis is always narrower than it should be by calculation; but in a subsequent publication the remark is not repeated. Pastorff thought he saw a phosphorescence on the dark part: but this was probably a deception.

2. The *Dark Spots*. The disc, when well seen, is usually mapped out in a way which gives at once the impression of land and water:* the bright part is orange,—according to Secchi, sometimes dotted with red, brown, and greenish points; B. and M. think it much less red than to the naked eye: the darker spaces, which vary greatly in depth of tone, are of a dull grey-green,† or according to Secchi, bluish, possessing the aspect of a fluid absorbent of the solar rays. If so, the proportion of land to water on the Earth is reversed on Mars: on the Earth every continent is an island; on Mars all seas are lakes; so that the habitable area may possibly be much more alike than the diameter of the planets. From the different distribution of the water (if such it be), long narrow straits

* Secchi's illustration is strikingly expressed: 'è tutto variegato come una carta geografica.'

† Herschel II. refers this colour to contrast. Jacob does not detect it. I have seen it with a 9 in. mirror, beautifully blue. The accurate Humboldt has puzzled himself about these colours. (Cosmos, IV. 503.)

are more common than on the Earth: Dawes has observed a singular forked shading, as if of two great contiguous estuaries. The dark spots were early seen, and a long series of drawings is extant from Hooke, Cassini, and Campani, in 1666,* to Jacob, Secchi, De La Rue, Lassell, Phillips, Lockyer, Dawes, and others in the present day, with some general correspondence,† but a difference of detail; which seems due in part to differences in telescopes, eyes, climates, and skill in delineation; in part to altered projection owing to the inclination of the axis,‡ shewing us sometimes more of N., sometimes of S. hemisphere; and in part also to changes in the planet's atmosphere. The older observers thought the spots variable: Herschel I. perhaps took the lead in supposing them to be permanent, an idea which Kunowsky, as late as 1822, fancied was due to himself. Schröter's work on Mars, the 'Areographische Fragmente,' which was to have contained 224 figures, was unfortunately left in MS. at his death in 1816,§ but he has stated that he and Olbers found them vary rapidly. B. and M. took up the subject with great spirit at the peculiarly favourable opposition in 1830, recovered some of Kunowsky's spots, and from their further observations in 1832,

* Humboldt, following Delambre, says that Cassini does not seem to have discovered the rotation of the spots till after 1670. He must have overlooked the figures in Phil. Trans. No. 14. Kaiser has shewn, from the MS. Journal of Huygens, that the latter discovered the rotation in 1659.

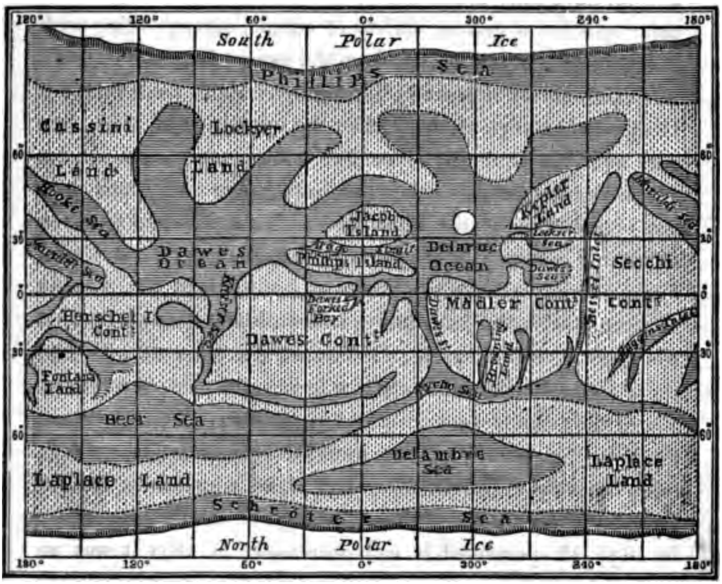
† Herschel I.'s combined figure in Phil. Trans. 1784, if *reversed*, will be not unlike B. and M.'s polar projections.

‡ 30° 18′, according to B. and M. and Herschel II. But is not this a mistake for the complementary angle? Hind gives, after Herschel I., 61° 18′ for inclination of axis to orbit of Mars; 59° 42′ for do. to Earth's ecliptic; obliquity on Mars, 28° 42′: but 90° − 59° 42′ = 30° 18′.

§ This MS. still exists in the hands of his descendants.

1834, and 1837, though the same hemisphere was not always equally visible, inferred their permanence. M., a little shaken as to this in 1839, retrogrades still further at Dorpat in 1841: the drawings, however, of later observers exhibit substantially many of the same forms, and notwithstanding numerous discrepancies, there seems sufficient evidence that most of the spots are really part of the surface. The distant view of the Earth, indeed, might be much of this nature; its outlines at one time distinct, at another confused or distorted by clouds: besides, one affirmative—the re-appearance of a spot—proves more, where there may be hindrances, than can be disproved by many negatives. At present, we can only form an approximate map of Mars; nor shall we ever know the N. so well as the S. hemisphere, as it is turned towards us in the planet's aphelion;—even were its markings equally defined, which B. and M. deny. Under favourable circumstances the dusky spots are not difficult objects; I have repeatedly been able to draw them with my 5½ f. achromatic; a much smaller instrument will sometimes shew the darker ones plainly; while on other parts of the globe, they are feeble even in large telescopes. Their motion will be very evident, and as the rotation is completed, according to Proctor, in $24^h\ 37^m\ 22{\cdot}735^s$, they will not vary greatly from night to night at the same hour. These remarkable features, with Proctor's provisional nomenclature, are represented in a design for which I am indebted to his kindness and that of Messrs. Longmans and Co. The expansion of the polar regions, due to the projection of Mercator, must be mentally corrected by the student; and in comparing the portrait with the original, allowance must be made for the perspective of a globe, where the foreshortening is much greater than we are frequently aware of, the eye being

probably early biassed by maps of the terrestrial hemisphere, in which it is artificially removed.



3. The *Polar Snows.* A spot surrounding either pole is so white and luminous as to have occasionally remained visible when a cloud obscured the planet: and frequently to seem, from irradiation, to project beyond the limb, as I have myself noticed. These zones were figured by Maraldi in 1704, who says they had been occasionally seen for 50 years;* in fact they could not long escape the telescope. They were thought to resemble snow before Herschel I.'s time; he gave consis-

* B. and M. erroneously make him the discoverer in 1716. A figure by Huygens, in 1656, may be meant as a rude representation of them.

tency to the idea by ascertaining that they decreased during the summer, and increased during the winter of Mars, and B. and M. have fully confirmed it, with the addition that the S. polar spot has a greater variety of extent, corresponding with its greater variety of climate from the excentricity of the orbit. Each pole comes alternately into sight, and both are sometimes visible on the edge at once, when the opposition of Mars concurs with his equinox. Herschel I. found they were not (or not always) opposite each other, both being sometimes in or out of the disc at the same time. M., and Secchi with the admirable achromatic at Rome, of $9\frac{6}{10}$ in. aperture and 15 f. focus, bearing ordinarily a power of 1,000, found the N. zone concentric with the axis, but the S. considerably excentric. It has been suggested by B. and M. that the poles of cold, like those on the Earth, may not coincide with the poles of rotation; —still they should be diametrically opposite. These observers found in 1837 the N. pole surrounded by a conspicuous dark zone, the only well-marked spot in sight, which they thought might possibly be a marsh at the edge of the melting snow: in 1839 M. perceived it had decreased; in 1841 it was no longer visible. About the opposition in 1856 I had interesting views of these zones, which did not seem exactly opposite to each other: the S. was surrounded by a very dark region, never seen by B. and M.; on the intervening limbs were occasionally luminous regions, so bright by contrast as to give an impression of *four* patches of snow, as in one of Cassini's figures in 1666: these were also seen by Secchi at the same time. In 1845 Mitchell with a great achromatic in America noticed a very dark spot in the centre of the snow, which disappeared the next night: * at another time he saw some

* Dawes saw (1847, Nov. 9) a minute black point near the middle of the disc.

movements in a small bright spot at the edge of the snow. Secchi in 1858 found the appearances at the poles irreconcilable with the idea of circular caps, and was forced to adopt the supposition of complicated and lobate forms. Crossley and Gledhill saw (1871, April 4) a very bright spot on SW. limb not far from, and closely resembling, the S. polar snow.

4. The *Atmosphere.* Such an appendage is implied in the formation of snow, the varying outline or distinctness of the dark spots, their usual disappearance towards the limb, and their greater clearness noticed by B. and M., and Lockyer, in the summer than the winter of Mars. Maraldi saw and delineated a dusky belt for a considerable time in 1704; something like it also appears in the designs of Schröter, who, from movements in these belts, inferred winds as rapid as our own. Some of Herschel I.'s figures shew white belts, and he says that besides the permanent spots he often noticed occasional changes of partial bright belts, and once a darkish one; we should however, perhaps, have expected that clouds would always reflect a brighter light than land or water. Dawes has at times noticed changeable white spots, as from clouds or snow. One of these, in the 'De La Rue Ocean,' seen by him 1865, Jan. 21, 22, 23, but invisible 1864, Nov. 10, 12, and looking 'precisely like a large mass of snow,' has been called 'Dawes's Ice Island.' The same, or more probably a similar one, was seen by me with 9 in. refl. 1871, Apr. 4.* Browning frequently noticed in 1867 the transit of faint white spots, becoming, as they neared the limb, almost as brilliant as the polar snows. The bright 'menisci' or crescents which some

* 1842, Feb. 3, A.M. rain fell over nearly every part of the United States, from the Gulf of Mexico to beyond Lake Superior, and from the Mississippi to far out in the Atlantic. The upper side of this vast cloud must have appeared as a great white spot if seen at the distance of Mars.

observers have seen illuminating the E. and W. borders of the disc may have had an atmospheric cause, as well as the numerous patches of yellowish and bluish light upon the limb described by M., at Dorpat, in 1841. The atmosphere, according to Dawes, is only of moderate density; and seems not to be the cause of the ruddy tinge, as this is most decided in the centre of the disc, while in 1864 he noticed (as indeed I did in 1862) patches of greenish light near the limb. Huggins has also found the planet reddest when its atmosphere was clearest, and remarks that the colour does not affect the snow. His spectroscope shewed a vaporous envelope similar to, but probably not identical with, our own: Janssen's indicated aqueous vapour. Cassini exceeded all bounds in supposing that the atmosphere could obscure small stars at some distance; this effect, resulting from the contraction of the pupil in a bright light, was imperceptible in the great telescopes of Herschel I., and the idea has been overthrown by the experience of South, who has seen one contact and two occultations of stars without change: in the last, his great achromatic, (now at the Dublin observatory,) $11\frac{7}{8}$ in. aperture and nearly 19 f. focus, actually shewed the star neatly dichotomized in emerging. This is not surprising, for the atmosphere, if in proportion to ours, would not extend more than $0''\cdot3$ beyond the limb when nearest to the Earth.

It is worthy of notice that Dawes could detect no ellipticity in this planetary globe.

A favourable opposition will occur in 1877.

The Minor Planets hardly come within the design of these pages, though the more conspicuous of them may sometimes be found by the Nautical Almanac without much trouble. But any investigation respecting the discs, supposed nebulous envelopes, and variable light of a few of these extremely minute bodies, belongs only to first-rate instruments.

JUPITER.

This magnificent planet is an excellent object, in view for months together, and for some part of every year, shining with a brilliancy which near the opposition casts shadows in a darkened room, and in the Earl of Rosse's reflector has been compared to that of a coach-lamp;* it is attended, too, by a most interesting retinue. In the latter even a very moderate telescope will shew one of the most diversified scenes in the heavens. Not only from night to night, but often from hour to hour, incessant changes will catch the eye; and since the orbits of all the satellites lie nearly edgeways with respect to the Earth, the retreating and advancing motions appear to intersect one another, and these miniature planets are seen overtaking, passing, meeting, hiding, and receding from one another in most beautiful and endless mazes. We begin with the features of the globe.

1. The *Ellipticity.* No heavenly body (except at times Venus) shews a disc so readily as Jupiter; a very low power will bring out his noble face, 11 times larger than our Earth;

* Bond II. has often seen it with the naked eye in high and clear sunshine.

and with higher magnifiers we shall soon perceive that it is not circular, but a little flattened N. and S.* Obvious as this is, it was doubted at one time by Cassini, and missed by Hooke, though he drew the spots of Mars, and directed particular attention to the polar flattening of the Earth. Astronomers differ as to its amount; from many comparisons and observations Main fixed it at a little more than $\frac{1}{17}$ of the equatorial diameter: Secchi gives $\frac{1}{18}$: Engelmann, from a mean of 11 observers, $\frac{1}{15 \cdot 82}$. Once noticed, it is so evident that a good eye will not tolerate the circular figures too often used to represent this planet: and the student who wishes to draw the belts should prepare oval discs beforehand, which may be done thus. Make a rectangle 15 high, 16 wide, on any convenient scale of equal parts; find its centre by intersecting diagonals; from this describe a circle touching the top and bottom, and then *pull out* as it were the sides of the circle to touch the ends of the rectangle, altering the curves by eye and hand till a tolerable ellipsis is produced: if many figures are wanted, cut one out neatly in card, and draw the others by means of its edge.

2. The *Phasis*. The orbit of Jupiter is so far external to that of the Earth that there can be but little defalcation of light—ordinary books say *none*: a diminished breadth is however measurable, if not visible, in our best instruments, and a moderate telescope will shew the *approach* of the gibbous form about the time of Jupiter's quadrature, in a slight shade along the limb furthest from the Sun. This was recorded by my-

* The beginner may be reminded that the points of the celestial compass only stand straight when the object is on the meridian; but at all times they may be verified by recollecting that the motion through the field is always from E. to W.

self as far back as 1838, May 30, but I believe I had seen it previously, as often since, with the 5½ f. achromatic: more recently, De La Rue and Secchi have mentioned it. I have thought it plainer in twilight than darkness; a fact in accordance with many similar observations by eminent astronomers.*

3. The *Belts and Spots*. Grey streaks across the disc, unnoticed perhaps for a time from their faintness in some seasons, must before long have been detected even by the early telescopes; and it would be found that, though always lying in one equatorial direction, they were not permanent in position, but subject to sometimes very gradual, sometimes very rapid changes, which, when we bear in mind the size of the planet, must often be on an enormous scale. The equator is frequently luminous, having on each side of it a broad dusky streak, beyond which a series of narrower stripes extend to either pole: but the arrangement is very uncertain in all respects except that of a general E. and W. direction; oblique,† curved, or ragged streaks are sometimes seen, and the belts are often interrupted, as well as varied by notched or wavy outlines. Occasionally they throw out dusky loops or festoons, whose elliptical interiors, arranged lengthways, and sometimes with great regularity, have the aspect of a girdle of luminous egg-shaped clouds surrounding the globe. These oval forms, which

* The most perfect telescopic vision is sometimes attained under unlikely circumstances—such as fog, twilight, and moonlight: every object is best seen under certain proportions of light and power and contrast, which are matter of experience; and in such experience lies much of the observer's skill.

† The change of inclination in one of these oblique belts in 1860 was very remarkable, and might be supposed to indicate that the atmosphere revolved faster at the equator than at some distance of N. latitude (Monthly Notices, xx. 243).

were very conspicuous in the equatorial zone (as the interval of the belts may be termed) in 1869–70, and of which the vestiges still remain, have been seen in other regions of the planet, and are probably of frequent recurrence. The earliest distinct representation of them that I know of is by Dawes, 1851, Mar. 8, but they are perhaps indicated in drawings of the last century. It is by no means easy to assign a reason for this prevalent configuration, which sometimes shews itself in a solitary ellipse (Gledhill and Mayer, 1869–70; Gledhill again, 1871). Schwabe has observed the whole disc traversed by minute parallel dark lines, most distinct in the dusky belts, where also they have been recognised by Jacob under finest definition. According to Schwabe the belts fade off by the formation of longish white spots, or bays, and return by a similar process; and in either case the two principal streaks frequently shew corresponding patches. The edges nearest the equator are usually the darkest and most permanent parts. The larger belts, especially, have at times a brownish, coppery, or purple hue: Secchi (1860) calls the principal belt red, with other alternate bands of green and white: but the more luminous equator sometimes exhibits a remarkable ruddy, yellow, or brown tint: this, which had formerly been noticed by Herschel (1790) and probably by Gruithuisen (1834 ?) was seen by Prof. Herschel in 1860, Carpenter in 1861–2, and has been more or less conspicuous ever since the autumn of 1869. Airy and Browning suspect a periodical return. Spots of very uncertain character are from time to time visible. They are occasionally luminous, more frequently very dark: one of the latter, seen by Hooke in 1664, and Cassini in 1665, was unusually permanent, having been observed, with many interruptions, till 1715; it even seems to have reappeared as late

as 1834,* always with the S. equatorial belt, though the belt has often been seen without it. An observation by South affords a beautiful illustration of the evanescent nature of some of these objects. 'On June 3, 1839, at 13^h 45^m (sidereal time) I saw with my large achromatic, immediately below the lowest [? edge] of the principal belt of Jupiter, a spot larger than I had seen before: it was of a dark colour, but certainly not absolutely black. I estimated it at a fourth of the planet's equatorial diameter. I shewed it to some gentlemen who were present; its enormous extent was such that on my wishing to have a portrait of it, one of the gentlemen, who was a good draftsman, kindly undertook to draw me one: whilst I, on the other hand, extremely desirous that its actual magnitude should not rest on estimation, proposed, on account of the scandalous unsteadiness of the large instrument, to measure it tricometrically (*sic*) with my 5 f. equatorial. Having obtained for my companion the necessary drawing instruments, I went to work, he preparing himself to commence his; on my looking however into the telescope of the 5 f. equatorial, at 13^h 45^m (*sic*), I was astonished to find that the large dark spot, except at its eastern and western extremities, had become much whiter than any of the other parts of the planet, and at 14^h 19^m these miserable scraps were the only remains of a spot which, but a few minutes before, had extended over at least 22,000 miles.' Gruithuisen once (1822) saw a small elliptical black speck close to the limb near the S. pole. A very different kind of

* According to Hind, however, these spots were on opposite sides of the equator. The spot, or rather spots, of 1834 had been seen by Schwabe in 1828, and by myself with a fluid achromatic in 1831 and 1832. Dawes observed a very large black spot in 1843. Two were visible at the close of 1858.

spots has recently been observed;—minute white roundish specks, about the size of satellites, on the dark S. belts. Dawes first saw them in 1849, Lassell in 1850, with his Newtonian reflector, of 2 f. aperture, 20 f. focus. Dawes has since given several striking drawings of them in the Monthly Notices of the Astronomical Society, and they have been seen in the 9 in. achromatic erected by Sir W. K. Murray in Scotland. They are evidently not permanent. Common telescopes will have no chance with them, or with the similar traces which Lassell has detected (1858) on the bright belts.—All these phænomena prove an envelope vaporous and mutable like that of the Earth,* without, however, necessarily inferring the existence of tempestuous winds: even in our own atmosphere, when near the 'dew point,' or limit of saturation with moisture, surprising changes sometimes occur very quietly: a cloud-bank observed by Herschel II. 1827, April 19, was precipitated so rapidly that it crossed the whole sky from E. to W. at the rate of at least 300 miles per hour; and alterations far more sudden are conceivable where everything is on a gigantic scale. The ancient astronomers soon recognised the signs of an atmosphere, and Huygens speaks of clouds and winds on Jupiter; but they seem to have looked upon the dark as the cloudy belts, forgetting that to an eye placed *above them*, vapours in sunshine would appear whiter than the globe beneath. Schröter made the same mistake, and Herschel I. for a time, though subsequently he perceived the probability that the dusky belts may be the real body of the planet. This is supposed to be established by the invisibility of the darkest spots when near the limbs, and the fading away

* The spectroscopes of Huggins, Buckingham, and Le Sueur indicate an atmosphere similar to, but not identical with, our own.

of the grey streaks towards their ends; but the argument is not quite conclusive: in the former case sufficient allowance may not have been made for foreshortening: the latter phænomenon is less evident than has been sometimes stated: it is not mentioned by Herschel I., though described and represented by his son: greatly exaggerated in the clumsy figures of B. and M., it does not appear in the elaborate design of De La Rue: and in fine air it is questionable with my 9 in. mirror. However, it may be admitted as the likelier alternative that the clouds are the more reflective portion of the disc. At any rate the atmosphere is not extensive enough to affect the brightness or motion of the satellites in passing behind the disc, as Dawes has proved with his 'solar eye-piece.' The equatorial direction of the streaks, and the swift rotation of the globe, appear to be connected, though in what manner it is not easy to explain, as the analogy of our trade-winds will be found insufficient: but the general aspect cannot be mistaken: and Piazzi Smyth, in his charming book 'Teneriffe,' has described in the most graphic manner the appearance of 'a windy sky' and the shapes of drifting and changing vapours, 'most picturesque clouds,' seen with the $7\frac{1}{4}$ in. achromatic on 'the peak of Teyde,' and beautifully delineated in his more scientific 'Report.' The great dark spots possess more stability, as though some portions of the surface cleared the sky above them for a considerable time; yet these, or rather the vapours round them, seem liable to displacement, as they do not always give the same period of rotation. This, however, according to B. and M., is very nearly $9^h\ 55^m\ 30^s$ for day and night.* The equator of this huge globe is therefore flying

* Airy, from Cambridge observations in 1834, makes it 9^s less. Schmidt finds it different from dark and light spots. His mean, 1866,

28,000 miles an hour, or between 7 and 8 miles every second! and a few minutes shew the movement of the spots, but puzzle the draughtsman. We must now proceed to

THE SATELLITES.

Are these little moons visible to the naked eye? The question has been usually negatived, as, though I (*i. e.* the first, or nearest) is about as far from Jupiter's surface as our Moon from the Earth, they are very minute, and overpowered by the planet's rays. Yet there have been exceptions. Benzenberg speaks of sixteen correct observations by three independent observers. A tailor, named Schön, at Breslau, who died in 1837, always and indisputably perceived I and III, when sufficiently distant from Jupiter. The Marquis of Ormonde is said to have seen them in the sky of Etna: Jacob and another have made out III at Madras: the missionary Stoddart at Oroomiah, in Persia, states that he could detect some of them in twilight, before the glare of the planet came out; and under the same circumstances two are said to have been more recently perceived by several persons at Devizes:* once (1832, Sept. 1), III and IV being on the same side, and far from Jupiter, I saw them, though not separately, through the concave eye-glass which corrects my near sight. Banks has seen I and II as one; III frequently, and once a glimpse of IV. II and III were seen separately by Boyd, 1860. Mason saw III, 1863. Buffham has frequently detected it. To try

is $9^h\ 55^m\ 46{\cdot}3^s$. Cassini had thought that bright spots rotated more rapidly if near the equator.

* This occurred about 20^m before a remarkable crimson aurora, 1859, April 21. Compare the observation of Venus, p. 53. Herschel I. found no perceptible effect on stars from auroral light.

this experiment, the planet had better be just hid behind some object, though I did not find it necessary. Any small telescope will bring them out, and a powerful instrument shews them even in the daytime.* Like Galileo, we may not at first perceive all four, as some are often invisible before or behind Jupiter, or in his shadow, but we shall soon recognise the whole train, and must attend to the following particulars.

1. Their *Identification*, a matter of some importance. III, if well situated, is usually brightest at first sight. IV goes much further than the others: but the best way is to consult the daily configurations in the Nautical Almanac, attending to the explanation of the symbols.

2. Their *Magnitudes*. Even a small instrument will shew that their light is steadier than that of stars; this arises from their possessing real discs, which will soon be 'raised' or drawn out, with increase of aperture and power; and beautiful miniature full moons they will be found to be; by no means, however, of one size. Engelmann, as a mean from various observers, gives I, 1″·081—II, 0″·910—III, 1″·537—IV, 1″·282.† This accounts in part for their different brightness, but a difference of reflective power must be combined with it in the general effect: and the individual light of each varies at different times. From many comparisons Herschel I. and Schröter considered that, like our Moon, they always turn the same side to their primary, and consequently different faces—some of which may be darkened by spots—to us: this has been confirmed by B. and M., but is still an inadequate explanation; its results are not always uniform, and singular

* Grover has seen III, 45^m before sunset, with only 2 in.

† Secchi made them 0″·985, 1″·054, 1″·609, 1″·496: but the two first measures were due to a single day: this anomaly will be again mentioned.

anomalies occur, especially with IV. As far back as 1707 Maraldi noticed that, though usually faintest, it was sometimes brightest (a variation which he ascribes to all the satellites); in 1711 Bianchini and another once saw it for more than 1^h so feeble that it could hardly be perceived; 1849, June 13, Lassell made a similar observation with far superior means. III is more consistent, usually taking the lead, yet Maraldi and Bond have sometimes observed the contrary; and many years ago, when I paid some attention to this subject, I have seen it repeatedly surpassed by IV. Engelmann thinks that, as a mean, II is relatively the most, IV the least luminous. In studying these changes we should hide the planet behind a narrow bar in the field, made by placing a thick wire, or strip of metal, or wood, or card, across the opening in the diaphragm, between the lenses of a Huygenian eye-piece: it is also advantageous to throw the satellites a little out of focus, as thus we *eliminate*, as mathematicians say, or get rid of, the impression of size, which might mislead the eye. Herschel I. used a convenient mode of expressing differences of light by stops of different value; thus III: I=II, IV would signify that III was very much brighter than I and II, and both these again a very little brighter than IV. The distances from Jupiter must be estimated in diameters of his disc, and the direction of each satellite's motion noted, to avoid confusing the near and remote halves of its orbit. The approximate periods here given will be of use: I—$1^d\ 18^h\ 28^m$. II—$3^d\ 13^h\ 15^m$. III—$7^d\ 3^h\ 43^m$. IV—$16^d\ 16^h\ 32^m$. Spots, as we shall presently see, may easily cause this variable light: but a stranger anomaly has been perceived,—the discs themselves do not always appear of the same size, or form. Maraldi noticed the former fact in 1707; Herschel I. 90 years afterwards, inferring also the

latter; and both have been since confirmed. B. and M., Lassell, Secchi, and Buffham have sometimes seen the disc of II larger than I, and Lassell, and Secchi and his assistant, have distinctly seen that of III irregular and elliptical; and according to the Roman observers, the ellipse does not always lie the same way: Buffham has often found IV the smallest of all, and irregular-looking. Phænomena so minute hardly find a suitable place in these pages, but they seem too singular to be omitted; and in some cases possibly small instruments may just indicate them; at least, with an inferior fluid achromatic reduced to 3 in. aperture I have sometimes noticed differences in the size of the discs which I thought were not imaginary.

3. Their *Colours.* Different eyes and instruments have here given different results. Herschel I. makes I and III white, II bluish or ash-coloured, IV dusky and ruddy. B. and M. call I rather bluish, II and III yellowish, IV always bluish. Secchi finds III sometimes whitish, generally red. Engelmann states that III is intensely yellow with low powers, and IV in achromatics a distinct dusky blue: but Dawes considered IV ruddy, as I have often thought; especially with 9 in. mirror. One unfavourable night of very thin white haze (1832, Oct. 8.) I found with $3\frac{7}{10}$ in. the colours of II, III, and IV unusually contrasted, though the discs were not well seen. Many times, both with the fluid and the $5\frac{1}{2}$ f. achromatic, I have fancied IV, when distant from Jupiter, and especially when viewed obliquely, encompassed with a little scattered nebulous light: but I have been unable to confirm this with better instruments. It certainly is very unlike III when they are near together; but the difference perhaps arises from colour.

4. Their *Eclipses.* The fading away or breaking forth of these little attendants, as they pass into or out of the great cone of shade which their monarch casts behind him for half a hundred millions of miles, is always interesting, and, when not too near the primary, within the reach of moderate instruments. The time being taken from the almanac, long enough beforehand to be quietly prepared with the most suitable eye-piece, a sharp look-out must be kept, as the diminution or increase of light, though not instantaneous, is speedy, especially with I and II. The planet had better be concealed behind a bar. Both Immersion and Emersion may be seen of III and IV, if not too near opposition; this can seldom be done with II, never with I, as the disc of the primary interferes. As the planes of their orbits pass so nearly through the Sun and our eyes, it seems remarkable that though respective occultations have been seen, there is no recorded instance of the eclipse of one satellite by the shadow of another.

5. Their *Occultations* by the globe of Jupiter: frequent, but not very interesting, as they shew no effect of the planet's atmosphere. Schumacher once saw a satellite hang on the limb, and seem to recede again, or make an indentation in it; Gorton, 1863, Apr. 26, found that II appeared and disappeared several times before occultation, perhaps from unsteady air; and at the same time Wray, with an 8 in. object-glass, saw it projected distinctly within the limb for nearly 20^s. Such anomalies are always worth recording.

6. Their *Transits.* The most beautiful phænomena of this beautiful system; often recurring, and not too difficult for a moderate telescope: the first known instance having been seen as early as 1658, with one of the old unwieldy refractors, by its skilful maker Campani, and my fluid achromatic of 3 in.

aperture having often given me a pleasing view of the scene. When a satellite is seen rapidly approaching Jupiter, on the *f* side (that is, the side *following* as the object passes through the field), a transit is inevitable; the satellite will glide on to the disc like a brilliant bead, and remain visible from its greater brightness for some distance,—according to South, $\frac{1}{4}$ or $\frac{1}{5}$ of Jupiter's diameter,—till it is lost in the luminous background, to re-appear after a time, and pass off in the same manner: or, if it traverses a dark belt, it may be perceptible throughout. But this is not all. An astronomer on Venus might witness a similar transit of our Moon across the Earth at the time of one of our solar eclipses, but he could scarcely if at all perceive the black dot of shade which our attendant casts upon us, as, from our comparative nearness to the Sun and the breadth of his disc, the cone of lunar shadow tapers so rapidly that its end falls short of the Earth in annular eclipses, and in total ones covers so small a spot on the surface that it would be invisible at any considerable distance,*

* The greater axis of the elliptical dark spot (neglecting the penumbra), which traversed England (very nearly in the course of the annular eclipse of 1858) during the last total eclipse, 1715, Apr. 22, is given at 150 miles, from Dartford to Oswestry, in a curious 'Description' or map of its path, by Halley, formerly in my possession, now in that of the Royal Astronomical Society. It is accompanied by the following characteristic notice:—'The like Eclipse having not for many Ages been seen in the Southern Parts of Great Britain, I thought it not improper to give the Publick an Account thereof, that the suddain darkness, wherin the Starrs will be visible about the Sun, may give no surprize to the People, who would, if unadvertized, be apt to look upon it as Ominous, and to Interpret it as portending evill to our Sovereign Lord King George and his Government, which God preserve. Hereby they will see that there is nothing in it more than Natural, and no more than the necessary result of the Motions of the Sun and Moon; And how well those are understood will appear by this Eclipse.'

notwithstanding the expansion due to the 'penumbra' or border of fainter shade extending over the region where the Sun's disc would be deeply but not entirely obscured. But Jupiter is so much further from the Sun that the shadows of his satellites form much longer cones, and falling but little diminished upon his disc, traverse it as singular and conspicuous objects, perfectly round and as black as ink, at varying distances *p* or *f*, (that is, preceding or following through the field,) according to the relative positions of the Sun, Earth, and Jupiter. When not near opposition, the shadow, especially of III or IV, may be far within the disc, while the satellite shines out in the deep blue sky. Occasionally two of these total solar eclipses may be seen at once on Jupiter, and it will be interesting to mark their unequal velocities and distances from the satellites to which they belong.—Such is the regular mode of transit. But remarkable exceptions are not uncommon, owing to the variable brightness of the satellites, which sometimes cross the disc as dusky or even black specks; when deepest, almost like their shadows. This seems to have been first noticed by Cassini in 1666, but was more fully described by Maraldi in 1707, and referred to rotating or variable spots. After a long interval Schröter and Harding reobserved the phænomenon in 1796,* and perceived that the spots were sometimes only partial. More recently the great telescopes of Lassell, Bond, Dawes, and Secchi have shewn

* In 1785 and 1786 Schröter repeatedly saw round black spots traversing Jupiter rapidly, like shadows of satellites. It seems very unlikely that he should have been misled by these *dark transits*, yet that suspicion will arise. It is quite unaccountable that Herschel I., and B. and M. should have passed by such obvious phænomena in silence. De Gasparis is said to have seen (1864, July 22) a black point on the disc, which passed off it in 15^m.

that these little moons* are liable to the formation of spots, just dark enough to be imperceptible in front of the fainter limb of Jupiter, but to start out rapidly in advancing upon the greater brightness of his centre, where they are generally dusky, irregular, and smaller than the shadow. I have sometimes seen them readily with my $5\frac{1}{2}$ f. telescope. South, who once found, with his large achromatic, two satellites of a light chocolate colour and their shadows on the disc at once, (which must have been, what he calls it, 'a glorious view,') says he never saw one black: but at Cambridge U.S. 1848, Jan. 28, when the shadows of I and III were both in transit, III itself 'was seen with the great refractor'† (Bond's) 'under very beautiful definition, as a black spot between the two shadows, and not to be distinguished from them except by the place it occupied. It was smaller than its shadow in the proportion of 3 to 5, not duskish simply, but quite black like the shadows.' Hartnup at Liverpool has also seen IV 'only a few shades lighter than the shadow.' Sometimes these spots have been so marked on III as actually to be visible to Dawes, Lassell, and Secchi, when it was shining freely on a dark sky; the former has given the following figures, of which the 1st repre-

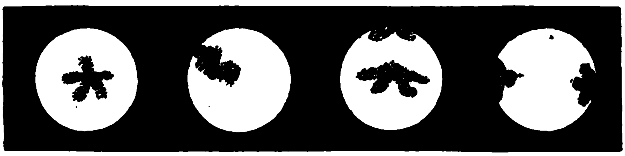
sents what was seen both on and off the planet, 1860, Jan. 24, 31; and the 2nd the appearance during transit, 1849, Feb. 11;

* With the exception of II, which Dawes finds always bright: the brightest of all for its size.

† $22\frac{3}{8}$ f. focus, 14·95 in. aperture, by Merz, Frauenhofer's successor.

so as to imply in each instance an unchanged position of the Satellite towards the Earth.* 1867, Aug. 21, when Jupiter was without visible satellites outside the disc, three being in transit at once, he again, and Barneby, saw the double spot, but on the opposite or SW. side. The 3rd fig. represents IV as he has sometimes observed it, with portions near the edge almost invisible from small reflective power. Secchi, who sees III reddish, and like the spotted face of Mars in a small glass, made designs during 1855, some of which are copied here,

Aug. 26. 19^h 20^m. Aug. 26. 21^h 10^m. Aug. 27. Sept. 9.



and from which he would infer a swift axial rotation; if so, these satellites must differ essentially from our Moon: that they do so to some extent is clear from the ephemeral nature of their obscurations, the same satellite often passing across Jupiter bright and dark at the interval of a single revolution in its orbit. An extract from my own observations, of a date long anterior to those of Lassell and Secchi, may be permitted as an encouragement to the possessors of ordinary instruments. '1835, Jan. 26. 10^h 30^m. 250 [power of $5\frac{1}{2}$ f. achromatic]. The 4^{th} [a little past inferior conjunction] was very pale, and rather ruddy; its disc not only smaller than that of the 1^{st} or 2^{nd}, but apparently imperfect as if spotted. Had the night been more favourable, this might have been a very interesting observation.'

* Gruithuisen says that on two occasions he has seen the light of this satellite reduced to a mere ring. Ingall, with a $5\frac{1}{2}$ in. dialyte, saw it (1870, Feb. 17) like a double star in contact.

From this change in the aspect of a satellite in dark transit, than which, as Dawes observes, no more delicate photometer could be applied to the different parts of the disc, we must infer a far greater difference of brightness between the centre and circumference of Jupiter than could have been suspected: a white disc would not be converted into a black one from mere contrast, unless the light of the background varied in a corresponding manner: and it is very strange that this variation is so little otherwise apparent to the eye. Browning however has detected it by means of a graduated darkening glass. On optical grounds we should hence deduce a very smooth surface for Jupiter, and one not covered with vapour, since this, as we see in the dense white clouds of our own sky, would not grow less bright towards the edge. One of the apparent anomalies of this system has been recently explained. The unexpected magnitude of the shadows, especially of IV, in transit, which had been noticed ever since Maraldi's time, has been shewn independently by Proctor and Buffham to be due to the darker part of the penumbra, the visible extent of which will vary with the optical power employed: and these diffused borders have actually been detected on several occasions by Lassell, Buffham, Gorton, and others. Appearances less easily accounted for are on record. Cassini once failed in finding the shadow of I when it should have been on the disc. Gorton saw it grey on one occasion. The shadow of II has been seen especially indistinct by Buffham, Birt, and Grover. South many years ago published in one of the public journals a most interesting observation, which I greatly regret that I cannot recover, but I am confident as to its tenour, which was, that in his great achromatic he perceived each of two shadows of satellites on Jupiter to be attended by a faint duplicate by its side; traces of which could be just detected with a smaller

telescope of (I believe) 5 f. But the most surprising is a phænomenon which requires, and possesses the highest attestation. 1828, June 26, II, having fairly entered on Jupiter, was found 12 or 13^m afterwards *outside the limb*, where it remained visible for at least 4^m, and then suddenly vanished. The authority of such an observer as Smyth would alone have established this wonderful fact; but it was recorded by two other very competent witnesses, and (what is especially remarkable) at considerable distances, Maclear at 12 miles and Pearson at 35 miles from Smyth at Bedford. Explanation is here set at defiance; demonstrably neither in the atmosphere of the Earth nor Jupiter, where, and what could have been the cause? At present we can get no answer.*

SATURN.

FORTUNATELY for the student, a common telescope will exhibit some part of the wonders of this superb planet, unparalleled in our own system, invisible elsewhere; and they whose expectations have not been unduly raised by designs made with the best telescopes will be delighted with the scene in their own. The minuter details require in general great optical perfection; but some of them may now and then be reached, though with a feeble grasp, by ordinary instruments, and our readers may have occasional access to more powerful means; it seems best therefore to be circumstantial. We shall describe the Globe, the Rings, and the Satellites, in succession.

* Gambart says that at the immersion of I, 1823, Oct. 19, 'le satellite a disparu et reparu plusieurs fois:' but in this case qu. as to the state of the air, or the eye?

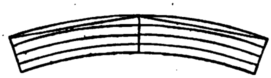
The *Globe.* Though about 74,000 m.* in equatorial diameter, second only to Jupiter, and between 9 and 10 times larger than the Earth, this noble ball has so little density that it would float like cork on water, which is about ¼ heavier, and therefore, if any were found there, would sink to its centre; while on the probable supposition that the density of the globe decreases outwards, its surface-material must be lighter still, and the conditions of existence there wholly unlike our own. Seidel has shewn that its reflective power, including that of its atmosphere, is only ⅓ of that of Venus, Mars, or Jupiter. Day and night, clouds and winds, summer and winter, the only steps in the analogy, leave an immense distance to be overpassed; and the tenfold nearer approach of modern astronomers has not bridged over the chasm which foiled the enquiries of Huygens, and kept him still in ignorance of the wonders beyond it.†

1. *Ellipticity.* There is no doubt of this compression, but much uncertainty as to its amount: the inclination of the axis, corresponding with that of the ring, causes some difficulty; the intersecting outlines of the ring occasion more, deceiving the eye,‡ so that at one time Herschel I. and others imagined

* Measurements differ a little; those adopted throughout cannot be far from the truth.

† 'Ad longinqua Saturni regna propius nunc quam antehac quisquam adivi, et usque eo progressus sum, ut vasti adeo itineris pars una centesima tantummodo reliqua fuerit: quam si quo pacto superare potuissem, quot, qualiaque . . narranda haberem!'

‡ Proctor has shewn very ingeniously that remarkable illusions are caused by the juxtaposition of lines of different character. This will be apparent from a diagram (taken from his in 'Intellectual Observer,' x. 23) in



which the two chords, though apparently curved, to most eyes at any rate, are really straight lines.

that the ball was doubly flattened, at the equator as well as at the poles. Others, especially Bond II., have thought the two hemispheres not precisely alike in flattening. The best values of the compression vary between a little less than $\frac{1}{9}$ and a little less than $\frac{1}{12}$: at any rate it is very considerable. It is of course best seen during the disappearance of the ring.

2. *Excentricity.* Schwabe, though perhaps anticipated in perceiving that the globe is not accurately central in the ring, first drew general attention to the fact, observed by him in 1827 with a $3\frac{1}{2}$ f. achromatic. It has been doubted, but seems established by measures which give the dark opening a very little smaller on W. than E. side:* the Roman observers considered it very evident, but rapidly variable, in 1842 and 1843: I have sometimes fancied it visible with the $5\frac{1}{2}$ f. achromatic. It has been thought theoretically essential to the stability of the ring.

3. *Belts* and *Spots.* The globe is diversified by darker and lighter bands, changeable, but always parallel to the equator. Herschel I.'s 'quintuple belt' of alternate light and shade is now seldom to be seen: usually there is a strong central whitish band, the brightest part of the ball; on each side of it a broad brown or somewhat ruddy zone, with many streaks and markings, generally parallel; then a similar greenish or bluish grey region extending to the poles, which are capped by a darker patch of the same tint, with sometimes a pale central space. Browning describes the colours in 1868, with a $12\frac{1}{4}$ in. mirror, as light cinnamon and bright azure blue. Strange to say, B. and M. missed these belts, which Huygens discovered with his old refractor, and Grover has often seen with only 2 in. of aperture.—Spots or streaks are uncommon,

* Gallet, the supposed discoverer in 1664, reverses this position.

and the instances easily enumerated: Cassini and Fatio, two bright streaks, 1683—Herschel I., 1780,* 1806—Schröter and Harding, 1796, 1797—Schwabe, 1847—Busch, a bright spot, 1848. Bond I., in 1848 and 1854, and De La Rue in 1856, figure some darker patches. Lassell and Jacob, 1852—Coolidge and Bond II., 1856—Dawes and Lassell, 1858—Secchi, 1861. From the unequal strength of parts of his quintuple belt Herschel I. found the rotation $10^h\ 16^m\ 0{\cdot}44^s$. Schröter from various spots, $11^h\ 51^m$, $11^h\ 40^m\ 30^s$, and rather more than 12^h. The precise period is probably not known. An appearance which indicated an atmosphere to Herschel I., —the hanging of the satellites on the limb previous to passing behind it, is as yet unconfirmed. The spectroscope of Huggins shews the existence of an atmosphere of similar quality to that of Jupiter; Janssen infers aqueous vapour in both. From the transit of Titan, however, Chacornac finds the reverse as to reflective power, the edges being brighter than the centre.

The *System of Rings*, so far as has been ascertained, is unique; the only level surface, or rather collection of level surfaces, that we know. From the combination of its inclined position, its parallelism with itself, and Saturn's revolution round the Sun, it will alternately shew each side to a distant spectator, and in two opposite points of the orbit come into an edgeways position and disappear. The whole revolution occupying nearly 29½ years, all the phænomena of increasing and decreasing breadth will be gone through in something less that 15 years, for each side of the ring: and the widest open-

* The object figured by Herschel I. in Phil. Trans. 1790, is called 'a strong, dark spot near the margin of the disc,' where even Bond's great achromatic fails to trace the belts, and where, on Jupiter, the darkest spots might probably be imperceptible through his atmosphere.

ing, when the breadth almost exactly equals half the length, having occurred in 1870, it is now gradually contracting to its edge-presentation in 1877; but unfortunately in a very unfavourable position for European observers. To a spectator in the Sun, the ring would vanish but once as it changed sides to him, being invisible, or nearly so, from its thinness; on the Earth, being neither in the centre of Saturn's orbit, nor at rest, we may find it disappear in four positions—either edgeways to Sun and Earth,—edgeways to Sun but not to Earth, when it will be too faint, each side having only a very little horizontal light,—edgeways to Earth but not to Sun, when, though enlightened, it will be too narrow to be visible,—or edgeways to neither, but having its dark side towards Earth: the motion of Saturn however carries it before very long through all these points, and the previously hidden side comes definitely into view. We must now consider it as it was in 1856 and 1870, when the ring at its greatest width projected beyond each pole of the globe: in this position it is brought out by a very small power—(I have seen it with about 20 on only 1⅓ in. aperture)—the blue sky being visible on each side through the 'ansæ' (or *handles*), as the semi-ovals of light are termed into which the ring is projected. Galileo's telescope, though it magnified upwards of 30 times, could not define it thus, and he imagined that he saw a large globe between two smaller ones: then followed a number of queer-shaped misrepresentations by various hands, till in 1659 Christian Huygens made for himself a refractor of 23 f. focus and 2⅓ in. aperture, which, bearing a power of 100, solved the mystery. His exulting father celebrated the discovery by a copy of verses, closed by a passage worthy of preservation, in which he thus anticipates for his son a fame as lasting as the firmament;

Gloria sideribus quam convenit esse coævam,
Et tantum cœlo commoriente mori.

The telescope now improved rapidly, and the cumbrous and troublesome refractor of those days was often exceedingly good for the kind of thing. 1665, Oct. 13, two brothers at Minehead with a 38 f. telescope discovered the principal division in the ring,* which ought to be called Ball's, after their name: it was rediscovered by Cassini in 1675, one of whose refractors, 20 f. long, with not quite 2½ in. aperture, bore a power of 90. A much lower power would not shew it all round, as Cassini seems to have seen it, even in a modern achromatic. But we must proceed to details, adopting Otto Struve's designation of the three principal rings, by the letters **A**, **B**, **C**.

1. The *Outermost Ring* (**A**), about 168,000 miles outside measure, was perceived by Cassini, as early as 1675, to be considerably fainter than the outer part of its neighbour; a small telescope will readily shew the difference. There seems reason to believe that its structure is either always, or temporarily, multiple. Short in the last, Kater in this century saw, on rare occasions, several concentric fine lines upon its surface. The strongest of these, named after Encke, who first drew attention to it in 1837, is perceived from time to time rather outside the middle of the ring. Jacob saw it constantly at Madras, and P. Smyth found it very distinct in the pure sky of the Peak of Teneriffe; Lassell and Secchi find only a dusky mark like a pencil line, Dawes and De La Rue consider it a black division.† Immediately within it, the latter ob-

* Humboldt was not aware of this fact.

† In 1851 and 1852 Dawes saw this line when Bond, Struve, and Lassell, with three of the finest telescopes in existence, missed it. It was subsequently seen dusky in Bond's. 1858, Apr. 17, during an unusual display of Saturn, Lassell could only detect a very slight shade.

server represents a brighter streak in the exquisite drawings taken in 1852 and 1856, with his superb reflector of 13 in. aperture. Secchi has perceived another most minute line interior to the first. With has seen several hair-lines upon **A** at once. Dawes and Coolidge (Bond's assistant), have seen a greater brightness at the inner edge, Lassell (at Malta) at both edges of this ring. Common telescopes of course break down here, yet I have once or twice suspected a streaky aspect with the $5\frac{1}{2}$ f. achromatic: but it is very strange that these markings have escaped many of the best telescopes, especially directed to Saturn,—those of the two Herschels,* Schröter, and Struve at Dorpat. Possibly they may be subject to obscuration or change.

2. The *Ring* **B** begins from its very sharp outer border with a luminous region, sometimes the brightest part of the whole system, though according to Schwabe variable, a circumstance which I have also noticed, finding it more conspicuous in 1853 and 1855 than in 1856 and 1857: the inner edge is very obscure; Schumacher and Dawes have seen it much better defined on one side of the ball. From one rim to the other there is an increasing shade, formerly considered regular, now found by Lassell, Dawes, and Secchi to consist of 4 or 5 concentric and deepening bands, compared by Lassell to the steps of an amphitheatre; each may be a separate ring, since fine black lines were at times traced here by Encke, De-Vico, and Coolidge,† and Bond's telescope shewed markings like narrow

* In an admirably perfect view of Saturn by Herschel II., 1830, Apr. 4, with his 20 f. reflector, $18\frac{3}{4}$ in. aperture, no subdivision could be traced 'with all possible attention and with all powers and apertures.'

† Herschel I. saw such a line in June 1870, for a few days on one ansa only. De-Vico's observations are not always satisfactory.

waves of light and darkness. De La Rue, and Dawes in another year, have seen a lighter central band. The innermost edge is sometimes brightened up—in other seasons it fades. I saw it in 1853 without any previous knowledge, on one ansa, with only $3\frac{7}{10}$ in. aperture: in 1856 it was less visible, and went beyond my range in 1857.

3. The *Ring* **C**, the crape or gauze veil, is one of the greatest marvels of our day. How it could have escaped so long, while far minuter details were commonly seen, is a mystery indeed. Schröter in 1796, with his great reflector, 26 English f. focus, 19 in. aperture, particularly examined the space on each side of the ball, and found it uniformly dark; if anything, darker than the sky.* Our great observers the two Herschels never perceived it. Struve measured Saturn repeatedly in 1826 with the superb Dorpat achromatic, 14 f. focus, $9\frac{6}{10}$ in. aperture, but missed it, though he saw the inner edge of **B** very feebly defined. In 1828 a fine Cauchoix achromatic of $6\frac{1}{3}$ in. aperture having been placed in the Roman observatory, it was seen, as an old assistant informed Secchi, both in the ansæ and across the ball, yet, strange to say, and little to the credit of Roman science at that time, *no notice whatever was taken of it.* Ten years later, in 1838, the matter fell into worthier hands;—Galle of Berlin, with a glass the counterpart of that at Dorpat, detected and measured it very accurately, and published his observations; yet they somehow went on the shelf till, in Nov. 1850, Bond in America, and our own Dawes, had each the honour of an independent and original discovery; and now everybody may find it with a sufficient aperture: it has been well seen with a $3\frac{3}{8}$ in. achro-

* Bond's telescope shews the same appearance between **C** and the ball. It has been seen also by Whitley, 1870.

matic by Ross; I saw faint traces of it with my $3\frac{7}{10}$ in.; anything larger, if good, is sure to bring it out.—Where was it, for so many years? Probably some change may have rendered the part projected on the sky more luminous; but it is not a new formation, for where it crosses the ball it has been seen ever since Campani's time, 1664: and it was even repeatedly noticed that its outline did not suit the perspective of a belt on Saturn, as it was supposed to be, or that of a shadow thrown by the ring: on this bright background it is so easy that Grover has seen it with a 2 in. aperture. It reaches halfway or rather more from the edge of **B** to Saturn: at its first discovery Dawes, and Otto Struve at Poulkova (the Czar's observatory), with the superlative achromatic by Merz, 22 f. 4 in. focus, $14\frac{9}{10}$ in. aperture, considered it to be divided in two by a dark line; but this has not been seen since; nor is it certain whether there is a division between it and **B**, or whether it is fainter towards its inner edge. Its generally slaty hue has been at times found different on the two sides of the planet, reddish and bluish; and a repeated interchange of these tints, noticed by Lassell and Dawes, may indicate rotation; its width and brightness in the two ansæ have been occasionally seen different; its narrowness in front of the ball has induced an idea that it is not in the same plane with the rings **A** and **B**; and, in 1861–2, some nebulous light attending the edge-view of the ring, on each side of the globe, as observed by Struve II. and Wray, might perhaps be the result of its perceptible thickness. Dawes, Jacob, and Lassell have discovered the very curious fact of its partial transparency, permitting the limbs of Saturn to be traced through it.* Possibly a similar material may fill Ball's division, as this has

* Perceived by Whitley (1870) with a $6\frac{1}{2}$ in. silvered mirror.

been sometimes seen not quite black, and Jacob has even followed the shadow of Saturn across it. Many other slight variations lead to the enquiry whether this grand system is really permanent in its detail. Secchi thinks the bright rings may be clouds in an imperfectly transparent atmosphere,* which is visible in the ring **C** and Ball's division; and the American mathematician Pierce considers it demonstrable that the ring is not solid, but may be a stream or streams of a fluid rather denser than water, adding, in the spirit of a true philosopher, 'Man's speculations should be subdued from all rashness and extravagance in the immediate presence of the Creator.' An idea suggested by Cassini II., that it may consist of a multitude of satellites, has been ingeniously advocated by Proctor, but does not seem at any rate applicable to **C**. The transit of the rings over a considerable star would perhaps give us some further information; but such events are very infrequent. Whiston states that Dr. Samuel Clarke and his father, about 1707 or 1708, saw a star with a 17 f. refractor between the ring and Saturn, but nothing of the kind has been since recorded. Dawes alone has seen, but under unfavourable circumstances, a star between 8 and 9 mag. pass behind the outer edge of **A**. In such a case, all attention should be given to the visibility of the star through at least Ball's division, and the dark ring. The shadow of the planet upon the rings is readily seen, except near the opposition, cutting off one of the four arms of the ansæ from apparent contact with the ball: Grover has perceived it with a 2 in. aperture. The outline of this shadow has often been found curved the wrong

* The ring was suspected to have an atmosphere by Herschel I. from the apparent threading of the minutest satellites upon it when reduced to extreme thinness.

has sometimes been invisible, when it ought to have been seen; Dawes thinks from an atmosphere. Schwabe and other observers have thought the belts not exactly parallel to the ring in this position.

The *Satellites.* The very confused way in which the members of this numerous retinue were formerly designated, by numbers counted in two different directions, has been superseded by Herschel II.'s ingenious nomenclature, in which the names reckoned towards Saturn are easily remembered in a Latin pentameter and a half—

> Iapetus, Titan, Rhea, Dione, Tethys,
> Enceladus, Mimas.

This arrangement has been since disturbed by the simultaneous discovery in 1848 by Lassell and Bond of an 8th, Hyperion, extremely faint, between Iapetus and Titan.—The lesser of them belong only to the highest instruments: the innermost has never been seen certainly with anything smaller than a $6\frac{1}{3}$ in. object-glass, and then only in the purer skies of Paris, Rome, and Madras: the next, though easier, is still very minute. But Titan, the leader, is very conspicuous, being equal to an $8\frac{1}{2}$ mag. star, so that it was discovered by Huygens in 1655, in which year it was also seen, though not suspected to be a satellite, in England, by Sir Paul Neil and Sir Christopher Wren. In fact, this little point of light, which may be seen with a 1 in. aperture, has in large telescopes a disc of about $0''\cdot75$, and probably ranks in size between Mercury and Mars. Its shadow was watched by Herschel I. in 1789 in transit across the disc of Saturn; Gruithuisen also saw it in 1833, and in 1862 it was observed by Dawes and

several others, including myself.*—Iapetus is not small, though probably from a spotted surface and rotation like our Moon, not always equally visible, being much brightest at his W. elongation.†—Rhea, Dione, and Tethys are more minute.‡ Dawes considers Tethys superior to Dione. Kitchiner states, from a friend, that by hiding the planet, they have been seen with $2\frac{7}{10}$ in. aperture; Banks has seen four with $2\frac{7}{8}$ in.; Grover two, with only 2 in.; $3\frac{3}{4}$ or 4 in. may be expected to shew all five. They must not be too near the powerful light of the planet, but they only depart from it respectively 9·6, 6·9, and 5·4 of its radii. Schröter found them variable like Iapetus, but brightest towards E. instead of W. The inclination of their orbits, nearly similar to that of the ring, by spreading them over the sky, increases the difficulty of distinguishing them from small stars in one night's observation. To a spectator placed on Mimas, revolving in less than 23^h at a distance of only 32,000 miles from the edge of **A**, the whole system of rings and the included globe would float before the eye in such a spectacle of grandeur and beauty as the imagination is wholly unequal to conceive.

* Banks saw it with $2\frac{7}{8}$ in. as easily as the shadow of I on Jupiter. Dawes also witnessed the immersion of Titan in the planet's shadow.

† The change, according to Herschel I., is equivalent to that from 2 to 5 mag. Cassini, however, had found it uncertain. So Banks, 1866. —A confusion exists in some astronomical works with respect to the relative size and variable light of this satellite and Titan.

‡ That Cassini with his inferior means should have not only discovered them, but traced their periods, reflects great credit upon his ability; it is gratifying to be able to subjoin the striking encomium of his Éloge: 'Les cieux qui racontent la gloire de leur Créateur n'en avoient jamais plus parlé à personne qu'à lui, et n'avoient jamais mieux persuadé.'

URANUS AND NEPTUNE.

These planets may be reached, but to no great purpose, with ordinary means. Uranus, being visible in clear weather to the naked eye, will be easily caught up in the finder by the help of the almanac, and will be large and planetary-looking in the telescope; its disc indeed subtends 4″, but I never found the light of $3\frac{7}{10}$ in. sufficient to define it perfectly; $5\frac{1}{2}$ in. dealt far better with it: with Lawson's 7 in. object-glass, bequeathed to the Greenwich Naval School, I have seen it beautifully, as a little Moon: no one has made out much more: Mädler has seen it elliptical, and measured the flattening: Lassell with his 2 f. mirror, and in the sky of Malta, once thought it possible there might be a spot: Buffham (1870–1) appears to have succeeded in detecting with a 9 in. With-Browning mirror, white spots, portions probably of a discontinuous belt, from which a rotation from N. to S. might be imagined. The two rings suspected by Herschel I. have long been abandoned, and Lassell has reduced the satellites to 4, which even the $5\frac{9}{10}$ in. object-glass of Smyth was incapable of reaching. Huggins and Secchi differ as to the details of its spectrum, but it is unquestionably a very extraordinary one, crossed by 6 broad absorption-bands, one corresponding with hydrogen, the rest of unknown character.

Neptune may be found in the same way, but will hardly repay the search; I have several times seen him, dull and ill-defined, with my $5\frac{1}{2}$ f. achromatic: his satellite, steadily seen by Dawes with an 8 in. object-glass, no common telescope of course will touch. But who can say how grand a spectacle he might present on a nearer approach? or what mysteries

might be developed in a spectrum much resembling, according to Secchi, that of Uranus? or that he is the most distant planet that obeys our central Sun? or what unexplored wonders may lie in still remoter space? 'Quis unquam exhaustas dixerit cœli copias?'* The advance of optical power may be expected either to open up fresh marvels, or prove to us that, as far as the dominion of our own Sun is concerned, we have reached the boundary of our knowledge.

COMETS.

Thou wondrous orb, that o'er the northern sky
Hold'st thy unwonted course with awful blaze!
Unlike those heavenly lamps, whose steady light
Has cheered the sons of earth from age to age,
Thou, stranger, bursting from the realms of space
In radiant glory, through the silent night,
Thy tresses streaming like the golden hair
Of Atalanta, or that beauteous maid
Pursued by Phœbus, upward shalt invite
Many a dull brow unus'd on heav'n to turn,
And many a bosom rend with deep alarm.

Where is thy track throughout the vast expanse?
Still onward hast thou urged thy bold career,
From that first hour when the Creator's hand
Impell'd thy fire along the fields of light,
Nor ever yet arriv'd within the verge
Of mortal ken, nor drank the distant beams
Of our inferior sun, unask'd by thee
To guide thee harmless on thy rapid way?

REV. JOHN WEBB (1811).

WHEN Kepler stated his belief, not merely that comets inhabited the æther as fishes the ocean, but that the ocean was

* Bianchini.

not fuller of fishes than the æther of comets,* his contemporaries probably amused themselves with his luxuriant fancy. Yet Kepler was not far wrong as regards number; for it is now believed that upwards of 4,000 have approached the Sun within the orbit of Mars during the Christian æra. A twelvemonth seldom passes by, in these days of telescopic activity, without the announcement of several; 1858 produced 8, and sometimes 3 and even 4 (as in Feb. 1845) have been in sight at once: but of late the scarcity of conspicuous ones has been very remarkable. The generality are faint, and so much alike, at least in ordinary telescopes, that they offer little attraction beyond the curiosity of watching their progress: this, where there are stars for sky-marks, may be sometimes traced from hour to hour, and, in connection with the enormous distances traversed, gives a grand idea of the majestic movements of the universe. But larger comets are often equally imposing to the naked eye and marvellous in the telescope; of which we had a splendid instance in the 'Donati,' or in astronomical language, Comet V, 1858, that is, the 5th in order of that year, and again in the less beautiful, but in some respects more impressive Comet II, 1861: while Comets III, 1860, and II, 1862, were not less worthy of notice for peculiarity of structure. It would lead us into too wide a field, as well as one already cultivated by abler hands,† were we to describe separately the

* Nec minus ætherem cometis refertum esse puto, quam oceanum piscibus. Quod autem rari apparent nobis, ingens ætheris vastitas in causâ est.

† See Hind's excellent treatise, 'The Comets' (1852) and Bond's 'Account of Donati's Comet,' Cambridge, U.S., 1858: but especially his admirable Memoir in 'Annals of Observatory of Harvard College,' iii. Pingré consulted 616 authors for his Cométographie (1783); and there were, in 1841, 382 works on the subject in the Czar's observatory at Poulkova.

more remarkable of these bodies; it will be better therefore to sketch a general outline, which may serve to direct our expectations in future. First, however, we will give directions for finding them, when invisible to the naked eye.

If a comet is too faint to be readily perceived by moving about, over the proper quarter of the sky, a hand-telescope with a large field (an opera-glass may answer well), we must take our larger instrument and 'sweep' for it thus: ascertain its probable position—not, of course, at the date of discovery, but at the present time, if the announcement gives a clue to it; put in the lowest eye-piece, point the telescope some way below, and on one side of, the supposed place of the comet, and gently move it horizontally right or left, as the case may be, till it points about as much on the other side. When your first 'sweep' has been thus completed, raise the telescope vertically half the breadth of the field, or not much more (as a faint object too near the top or bottom might be missed), and sweep back again the same distance the reverse way, ending pretty nearly where you began, but of course half a field higher; raise again another half field, and sweep on, till either the comet sails across the field, or you are evidently pointing much too high for it: in which case you may conclude that it is too faint for you, or has gone away so far as to make further search useless. The movement may of course as well be begun above as below the supposed place of the comet. This process of sweeping is equally available for finding Mercury or Venus in the daytime, or minute stars or nebulæ at night; the chief difficulty lies in so proportioning the vertical movement that the object shall not escape between the sweeps; this is easy with rackwork, as the breadth of the field, and the suitable number of turns of the handle may be

previously ascertained by trial on a terrestrial object; with a plain stand there is little trouble in it where stars occur frequently to guide the displacement of the field; but by day, or in twilight, or in barren tracts of sky, sweeping without rack-work is less certain, and may require to be repeated.

The light of most comets is too faint for high powers, and demands a contrast with the dark sky which small fields do not admit: to get the whole extent of head or tail the lowest power should be chosen, and for the tail the naked eye will be more effective than any glass, except the appropriate instrument called a Comet-finder: high powers may be used for the details of the nucleus, but the contraction of the field and the want of contrast must always be allowed for. Small comets are frequently nothing but luminous mists without trains, sometimes without central condensation;—as we ascend in the scale, nuclei, trains, envelopes, and various anomalous appearances succeed, depending no doubt upon diversities in the materials of the comets themselves, as well as on their degree of approach to the Sun;—even Venus was thought to have influenced the aspect of 'the Donati,' as it passed near her. In common language, a comet consists of *head* and *tail*; but we have to make a telescopic analysis, and shall begin with

1. The *Nucleus*: the most luminous part, occupying in a general sense the centre of the head. It is sometimes absent in telescopic comets, which are mere fogs, permitting the minutest stars, even such as would be effaced by the slightest terrestrial mist, to be seen through the very centre; —thus Herschel II. saw a group of 16 and 17 mag. stars through the heart of the comet of Biela in 1832: from this diffused state they present every stage of condensation, including sometimes a sparkling or granulated appearance, up to the aspect of a star, which has occasionally, as in 1744, equalled Venus in

brightness, and been visible to the naked eye in broad noonday, or, as in 1843, blazed out yet more splendidly like a bright white cloud, close to the glowing meridian Sun.* High powers, however, usually dissolve any apparent solidity, and different instruments may give very different sizes to what looks like a planetary disc, throwing much doubt upon its reality: sometimes a very minute point (as Herschel I. found in 1807 and 1811) holds out against any magnifying; and this—like broader nuclei—is not always central in the head. In some comets (1618, 1652, 1661, 1707, Winnecke's 1869) the nucleus seems to have been composed of separate masses,—a marvellous structure; † would that we could study it with modern advantages! Had 'the Donati's' nucleus passed about 20′ further N., it would have gone right over Arcturus—and we should have obtained some negative information at any rate as to its composition. Miss Mitchell alone seems to have witnessed the central transit of a comet (1847) over a 5 mag. star, which shone through it unchanged: some minor examples are less conclusive.‡ Were a defined

* Other comets visible by day (omitting some questionable ones):—A.C. 43, the star of 'the mightiest Julius,' which appeared during the games held soon after his assassination, and gave rise to the star on the forehead in his coins and statues;—1106, 1402, 1577 (Tycho's great comet), 1618. That of Feb. 1847 was seen by Hind, and that of Aug. 1853 by Hartnup and Schmidt very near the sun; but in each case with the telescope, in which they shewed planetary discs. Donati's comet was not visible, except with very powerful instruments, by day.

† There is a strange story of visible internal movement among these subordinate nuclei in 1618—as if of coals stirred in a fire. This seems like a bad telescope or an alarmed observer—yet where all is mystery, neither credulity nor its opposite is the part of wisdom.

‡ Donati saw a 7 mag. star enlarged so as to shew a sensible disc, when the nucleus of Comet III, 1860, passed very near it. Stars are said to have started, or become tremulous, during occultation by comets.

phasis to show itself, a certain amount of density might be inferred; but, if we except 'the Donati' as seen by Dawes in daylight, Oct. 8, this has never been satisfactorily the case, as the retroverted form often assumed by luminous sectors throws a doubt upon the observations. The darkness close behind the nucleus in 1858, if not real shadow, seemed at least to prove that the nucleus was not permeable to the solar energy, in whatever way exerted, and that it had no rotation upon an axis. The arrival of the next great comet will be a season of absorbing interest. The spectrum analysis, first of Donati, subsequently of Huggins and Secchi, has shewn not only the native light of 7 small comets, but, what had been little anticipated, their gaseous character, the comets of Winnecke II., 1868; I., 1871; and of Encke giving a spectrum corresponding with that of the *vapour of carbon*:—a discovery so much the more unexpected, as this element is peculiarly unsusceptible of such a modification. There can now be little doubt that such is the constitution of larger specimens also: but probably with much variety in composition: as the acknowledged difference in colour makes sufficiently evident.

2. The *Coma* is the sphere of mist around the nucleus, forming in popular language the *head*; this is sometimes of considerable extent—2° 40′, or 5 times the Moon's diameter, in 1770, when the nearest recorded approach of a nucleus to the Earth took place, of 1½ million of miles. The coma fades away into the surrounding sky, with an outline, including that of the commencing tail, usually considered parabolic; Bond, however, found in 1858 that its section approached much more nearly to a catenary curve. Its denser part, if distinguishable by any set-off or outline, is called

3. The *Envelope*. This is an interior and brighter layer

of mist, suspended as an atmosphere around the nucleus, at least where exposed to the sun: in Donati's comet some observers (amongst them myself) carried it a good way round the back of the nucleus; but usually it turns straight off on each side to form the commencement of the tail: within it is sometimes a darker narrow band, separating it from another interior and brighter envelope.* In 1858 no fewer than four such dark spaces at once were sometimes shewn by the great achromatic at Cambridge, U.S., indicating the consecutive rising of five shining waves, which had spread themselves in succession outwards from the nucleus; the latter seeming to diminish in size and brightness after each of these emissions of luminosity. Mädler at Dorpat noticed an actual increase of one of these envelopes from 18″ to 27″ in 2^h. In 1811 the whole coma and envelope were raised in one parabolic mass from the nucleus, which was surrounded by clear dark sky on every side: when the extreme diameter of the luminous cloud amounted, according to Schröter, to 947,000 miles, considerably exceeding the bulk of the Sun, and almost doubling the Moon's orbit. As this comet receded, the dark space became indistinct, and the envelope sank finally down upon the nucleus. Envelopes sometimes contain dark spots and streaks (1858), and more frequently brushes or fans of light, where the shining matter seems to stream out from circumscribed portions of the nucleus; these are rapidly variable, and in Halley's comet at its return in 1835 shewed such a libration from side to side, traceable from hour to hour, that Bessel inferred some powerful polar force unconnected with gravity.

* Huggins has made the important remark that these non-luminous spaces may correspond to a condition of the vapour too cool to emit light, and yet not condensed so as to reflect it.

Such a swinging was less distinctly recognised in 1858. In Comet II, 1862, in which these aigrettes were very striking, Secchi and Chacornac found no motion of this kind, but that the jets proceeded alternately from different parts of the nucleus. The envelope and coma together form the origin of

4. The *Tail*. This, when not greatly foreshortened, appears as a long cylinder or more usually cone, widening in general as it advances, and shewing a hollow structure by an interior darkness. There seems, however, a doubt of the adequateness of the explanation; since the perspective of 1858 required a very different proportion either of the *breadth*, or the *intensity* of the dark space: some other cause may possibly be combined with vacancy to produce the effect. This interval in the Donati was very dark close behind the nucleus; Schwabe found it darker than the twilight sky, and Dawes and Hartnup considered it *real shadow*: in 1811, however, such a vacancy surrounded the nucleus on every side. The division into two streams effected by it was seen with the naked eye in the great comet of 1577, which astonished Tycho at his fishpond before sunset, and it has been frequently noticed since the discovery of the telescope; in 1843 it was absent; and a brighter ray filled the middle when Halley's comet in 1835 was withdrawing from the Sun. The preceding stream according to the comet's motion is usually brighter and sharper defined, as well as curved backwards. Kepler noticed this in 1618, and compared it in his own graphic way to the appearance of a heap of corn swept over by the wind in the threshing-floor: and no one will forget it who saw the form of the Donati.*

* Towards the close of its appearance, the American observers noticed a reversal of the brightness and definition of the sides of this comet's tail. They also found, contrary to the common opinion, that the plane

It has been usually referred to motion through a resisting medium: but Pape, from an elaborate investigation, finds that the curvature may be explained by the combination of the comet's motion with a repellent power in the Sun. The axis of the tail was calculated by him to differ 6° 18′ from exact opposition to the Sun, being left a little behind;—a deviation of which there have been previous examples. The length of the tail is sometimes enormous. According to Boguslawski, that of the wonderful comet which in 1843 nearly grazed the surface of the Sun, and, as Secchi expresses it, issued from it like a dart of light, was cast away to the almost incredible extent of 581 millions of miles—more than 6 times the distance of the Earth from the Sun, and crossing the orbit of Jupiter: and this astounding stream, the longest object, as far as our senses can reach, in all space, must have been shot out with an equally inconceivable velocity after passing the perihelion; for, but a short time before, the head was on the other side of the Sun, half round which it had been whirled in $1\frac{1}{2}^h$ or 2^h, and under such circumstances the whole direction of the same tail could not be supposed to have been reversed. Even should the length be considered to be overstated, we certainly have before us here one of the greatest marvels in the universe.—Minor trains are occasionally seen; in some cases (1769, 1811) the prolongations of an outer envelope; in others apparently separate branches (1806, 1843); according to Chéseaux, six of them, each hollow, formed a glorious fan in 1744. A straight, long, narrow, and very faint ray of this kind, directly opposite to the Sun, was seen by several observers steadily preceding the great curved tail in

of its curvature was not identical with that of its motion: how this can be reconciled with Pape's theory does not appear.

1858. The grand visitor of 1861 had a straight and a curved tail, the latter of which probably swept over our globe, or, according to Liais, buried it to a depth of 110,000 leagues. From certain periodical returns of lateral streams, Dunlop in 1825 inferred a rotation of the tail in $20\frac{1}{2}^h$, and similar appearances were noticed in 1769 and 1811, but the explanation is perhaps precarious, from the immense velocity required. An additional stream has sometimes, though rarely, been directed *towards* the Sun; this extraordinary phænomenon, called an *anomalous tail*, was noticed in 1824, when it was longer and brighter, though narrower and more tapering, than the usual one; subsequently it was found recorded that the grand comet of 1680—Newton's comet—had left a similar glowing wake upon the æther; and it has since been noticed in 1845, 1848 (Encke's,—perhaps again in 1871), 1850, and 1851.* The principal tail in 1858 was seen by the Americans crossed obliquely by a number of brighter bands like auroral streamers, diverging from a point between the nucleus and the Sun.

A few other details should be noticed. *Coruscations* or flashings have been often remarked in the tail: that of 1556 was said to waver like the flame of a torch in the wind; and numerous other instances might be given, before and since the use of telescopes. The accurate Hooke took many precautions before he satisfied himself of their reality in 1680 and 1682, and Schröter stoutly maintained their existence in 1807, referring them to electricity or some analogous cause; others negative them as too rapid for the progressive motion of the light by which we should see them,—an objection, how-

* One of the three short rays, besides the tail, seen in 1577, may possibly have been of this character.

ever, applying only to foreshortened tails,—and treat them as illusions depending on our own atmosphere, or the uncertainty of weary sight. Polarization experiments concur with spectrum-analysis in discrediting their reality, by shewing that the tails, as well as comæ, shine by reflected light, owing probably, as Huggins suggests, to the cooling of the incandescent material of the nucleus. These researches have of late made a rapid stride. But many points are still very incomprehensible. 'Omnia incerta ratione, et in naturæ majestate abdita.'*

The *colours* of comets differ; a wide margin must be left for the superstition of the ancients, who dreaded the herald of disaster, 'terris mutantem regna cometen,'† and held it as a malignant genius that

> —— from his horrid hair
> Shakes pestilence and war.

Those who noticed the fiery hue of the sabre-like comet that passed to the E. at the commencement of the Crimean war will understand with what feelings our fathers would have gazed upon it, like the astonished spectators of the comet of the Norman Conquest, represented in the Bayeux tapestry with the inscription 'isti mirantur stellam:' nor will the exaggeration of those beautiful lines seem unnatural,

> —— liquida si quando nocte cometæ
> Sanguinei lugubre rubent.‡

It is however certain, both from the Chinese and modern observations, that there is much general difference in respect

* Seneca.

† Lucan. The 'comet-dollars' still existing in Germany are a curious evidence of this feeling as late as 1664. See Illustr. Lond. News, July 20, 1861.

‡ Virgil.

to colour:* Herschel I. even found the nucleus of the same comet (1811) pale ruddy, the envelope greenish or bluish green: and a similar contrast was noted by Struve I. in Halley's comet in 1835, and by Winnecke in 1862. That the Sun induces in them a polar force superior to that of gravitation—the hypothesis, in the main, of Olbers—is most probable from the form of the envelope and tail, as if repelled alike from the nucleus and Sun: and that a certain portion of the rarer material is dissipated during the perihelion passage is evident from the very aspect of a tail such as that of 1858, whose restoration to the rapidly advancing nucleus is, to our apprehension, an impossibility. And in this, and in the destructive resistance which one comet (that of Encke) is known, and all may be presumed, to suffer, from the denser æther around the Sun, we find a striking indication that our system was not made to be eternal. The perfect balance of its construction might at first lead to another impression, and seem to countenance the old objection, that 'all things continue as they were from the beginning of the creation.' But here is evidence to the contrary—a slight but decisive symptom that—'they all shall wax old as doth a garment'—that 'they shall be changed.' A similar cause has probably been acting upon the comet of Biela; whose separation into two parts is one of the marvels of modern astronomy.† Single in all previous observed returns, (those of 1772, 1805, 1826, 1832,) in 1846 it became elongated, and then threw off a portion which increased till it rivalled and even for a short time surpassed its parent, each

* This comes out well chemically. The 'Donati' was photographed: with Comet II., 1861, it was found impossible, even by De La Rue.

† Liais at Olinda saw a second smaller and fainter nebulosity on several nights by the side of Comet I. 1860, previous to its disappearance. Astr. Nachr. 1248.

having at one period a starry nucleus and short tail, while they were connected by faint streams of light: and thus they continued in sight for more than three months, keeping a distance of something more than 150,000 miles, the companion being the first to vanish. When next seen by Secchi, in 1852, the distance was more than eight times greater, being 2^m in RA, and 30′ in Declination, as though they were becoming independent bodies: their next favourable return (1866) was looked for with no common interest; but they were not seen, and probably will never again be seen by mortal eye. Nor has the larger comet of De-Vico, discovered by him in 1844, with an apparent period of $5\frac{1}{2}$ years, ever shewn itself again —it has

> —— 'wandered away alone,
> No man knows whither.'

The identity of the orbits of two comets (II, 1862; and I, 1866, believed to be the same as that of 1366) with the paths of the meteor-showers in August and November is one of the most remarkable of modern discoveries, for which Schiaparelli has recently received the Gold-Medal of the Royal Astronomical Society. It is however needless, in a treatise like the present, to make more than a passing allusion to a subject of this nature.

PART III.

THE STARRY HEAVENS.

Lift up your eyes on high, and behold Who hath created these things, that bringeth out their host by number: He calleth them all by names by the greatness of His might, for that He is strong in power; not one faileth.
ISAIAH, xl. 26.

IF the Solar System had comprised in itself the whole material creation, it would alone have abundantly sufficed to declare the glory of GOD, and in our brief review of its greatness and its wonder we have seen enough to awaken the most impressive thoughts of His power and wisdom. But that system is but as a single drop in the ocean. What boundary may be set to creation we know not, but we can trace it sufficiently to perceive that, as far as our senses are concerned, it cannot be distinguished from absolute infinity: and in leaving our Sun and his attendants in the background, we are only approaching more amazing regions, and fresh scenes will open upon us of inexpressible and awful grandeur. We are now to contemplate not one Sun, but thousands and myriads:—not a planetary system of subordinate globes, but aggregations of Suns;—pairs, groups, galaxies of Suns—'the host of heaven,'—all independent in unborrowed splendour, yet many evidently, and all by clear implication, bound together by the same universal law which keeps the pebble in its place upon the surface of the earth, and guides the falling drop of the

shower, or the mist of the cataract. Many of these Suns may probably be smaller or dimmer than our own, yet others unquestionably far surpass his splendour; while as to distance, their remoteness is so inconceivable that light itself, flying with a speed which would encircle the Earth nearly 8 times in one second, only shews them to us as they formerly were, —some, years,—others, centuries,—others perhaps whole ages back, even in the first dawn of creation. Here is indeed a field where enterprise cannot be thrown away, nor perseverance fail of its reward.

We must, however, remember that, though they are Suns which we are contemplating, and though the mere aspect of some of them in a large telescope well bears out the assertion,* yet a great proportion are diminished by distance to the minutest points of light, and can only be distinctly seen under favourable circumstances. We cannot therefore expect uniform success; in fact, the more delicate objects of stellar astronomy are not only among the severest tests of the telescope and the eye, but are peculiarly liable to be affected by atmospheric indistinctness, and require the most propitious skies. The cautions suggested in Part I. will be especially applicable here.

An original investigation of all the objects worthy of notice, even in a popular sense, in the starry heavens, would have been the attempt of a lifetime, rather than of such occasional hours of leisure as I could command: an unverified selection, on paper, from a standard list formed with a very different design, would have been an easy, but not a satisfactory task:

* The approach of Sirius to the field of H.'s 40 f. reflector is said to have been ushered in by a dawning light, and its actual entrance to have been almost intolerable to the eye: yet the 4 f. mirror was far from good. What must be the blaze of this star in the Earl of Rosse's telescope, with a speculum of 6 f., of much higher reflective power!

a middle course has therefore been preferred. All such of the 850 Double Stars and Nebulæ of Vice-Admiral Smyth's Bedford Catalogue as my $3\frac{7}{10}$ in. of aperture could be expected to reach, were examined in succession, and those only retained for our purpose which seemed to possess sufficient general as well as scientific interest, and might serve as specimens of the universal profusion: and as in such a review a number of other objects, beautiful to the popular eye, though unimportant perhaps to the professed astronomer, presented themselves unsought, many of these have been added to the list, as well as many from Struve's 'Mensuræ Micrometricæ,' of which those examined by me are distinguished by brackets [ ]; the rest, included in parentheses ( ), are selected without personal observation, chiefly from Struve, either as obviously suitable for our purpose, or as instances of the many hundred similar objects in that great work. To these, the attentive student will be continually gathering fresh groups and combinations, especially from the crowded fields of the Galaxy;—a very little experience will convince him of the unspeakable richness of the firmament.

From a pressure of other employments, the interval since the first appearance of this little work has not added much original matter to the following catalogue. But it is to be hoped that some zealous lover of this great display of the glory of the Creator will carry out the author's idea, and study the whole visible heavens from what might be termed a picturesque point of view. This would involve nothing more than a sufficiency of optical power, of leisure, and of patience bringing with it its abundant reward. By a suitably arranged plan, every part of the sky might be swept over in succession, and the principal instances of intensity of colour, or elegance

or singularity of grouping having been noted, the materials would be prepared for a most interesting work—a *Handbook of the Wonders and Beauties of the Starry Heavens.*

A well-adjusted equatorial telescope will readily find anything in the following list from the position there given; otherwise recourse must be had to a good globe or map. The larger Star-Maps of the Society for the Diffusion of Useful Knowledge were, till of late, almost indispensable to the student, notwithstanding a very objectionable amount of distortion towards the sides and corners; but they have now been, except for very minute stars, superseded by the excellent Atlases of Proctor, which are comparatively free from this annoying defect, and the smaller of which is specially intended as a companion to the present work. The stars, clusters, and nebulæ in the following pages are divided into constellations, which are arranged alphabetically, and accord with those in the Bedford Catalogue: a few unimportant discrepancies in the companion atlas, which have arisen from the reference of the latter to another standard, the British Association Catalogue, are explained in the preface to the atlas, p. ix.

In the arrangement of the double stars in each constellation, precedence is given to brightness in the larger star of each pair, though great exactness in this respect has not been aimed at, and from the uncertainty of magnitude-estimates would hardly have been attainable. Pairs whose connection is ascertained are termed 'binary.'* The *magnitudes* and *colours* of the Bedford Catalogue are everywhere adopted, if it is not otherwise specified; but comparisons are given from the results

* It should be observed that where change is demonstrated it does not necessarily infer binarity, as it may arise from proper motion in one or both of the components.

of other observers; and my own observations and remarks are distinguished by brackets, at least where ambiguity might arise: some excuse may be alleged for their admission, since the eyes and instruments of those who may use this treatise are much more likely to resemble my own than Smyth's: observations also of little individual worth may ultimately by accumulation and comparison acquire some value. *Magnitudes* have been very differently, and we may venture to add, sometimes very uncertainly rated by different observers: a fresh scale, introduced by Struve, and including in 12 degrees the 20 of Herschel II. and Smyth, is preferred by many great authorities. I have, however, not departed from those in the Bedford Catalogue (which are assumed from Piazzi for the brighter star in each pair), because the equivalents, in another scale, of the whole and half magnitudes which alone were employed by Smyth, would in most instances mislead the student, by giving an impression of minuter fractional determination than that observer thought fit to employ. For Struve's objects his own scale is retained.

The following comparative table of the magnitude scales of Smyth, Struve, Herschel II., and Argelander, for which I am indebted to the kindness of G. Knott, Esq., will be found of great value. It is restricted to telescopic magnitudes, the larger ones being fairly accordant.

Sm.	Σ	H.	A.
6	5·7	6·4	5·9
6·5	6·3	7·0	6·4
7	6·5	7·4	6·8
7·5	6·9	7·8	7·5
8	7·4	8·2	8·0
8·5	7·9	8·8	8·6
9	8·3	9·5	9·0
9·5	8·9	10·1	9·4

Sm.	Σ.	H.	A.
10	9·3	10·4	9·4
11	10·0	11·3	10·0
12	10·4	11·7	10·6
13	10·7	12·5	11·2
14	10·9	13·3	11·8
15	10·9	14·5	12·4
16	10·9	15·9	13·0

A subsequently published collation by Herschel II. of his own magnitudes with those of Σ will form an interesting addition.

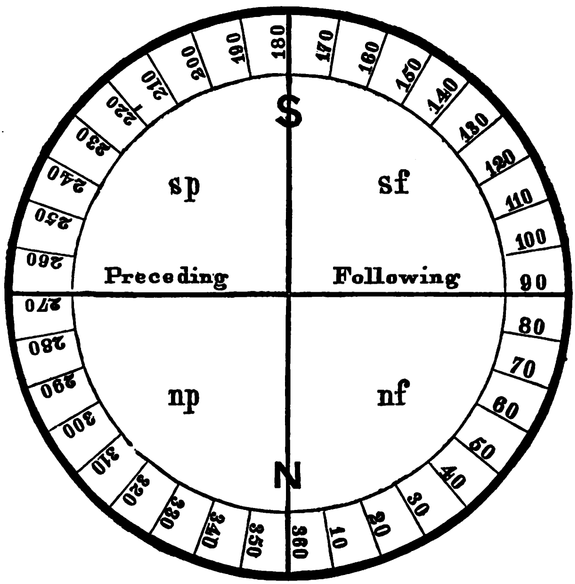
Σ.	H.	Σ.	H.	Σ.	H.	Σ.	H.
2.60	3	6·40	7	9·30	11	10·87	15
3·10	3·5	6·85	7·5	9·60	11·5	11·13	16
3·60	4	7·30	8	9·80	12	11·38	17
4·10	4·5	7·70	8·5	10·00	12·5	11·61	18
4·60	5	8·10	9	10·18	13	11·82	19
5.05	5·5	8·50	9·5	10·36	13·5	12·00	20
5·50	6	8·80	10	10·54	14		
5·95	6·5	9·10	10·5	10·71	14·5		

The *range of visibility* depends of course on the light of the instrument and the sensitiveness of the eye. Our great observer, Dawes, had a sight capable of detecting very minute points with small optical means: with an eye and telescope of average quality my experience leads me to believe that the range of a $3\frac{7}{10}$ in. object-glass will terminate among 11 mag. stars (of Smyth's scale), though from some unknown cause,—possibly, as Smyth suggests, peculiarity of hue,—smaller ones are sometimes to be caught. Where I have ventured to note any discrepancy as to magnitude, it has been with a view to assist in detecting variations of light: Schröter suggested, and Humboldt is of his opinion, that variability may be the inseparable condition of all light, and the evidence of its probability is continually on the increase. As to estimates of *colour*

there is also great difference, arising from the differences of telescopes and eyes, and even of the states of the same eye: still there are limits of disagreement, and it is desirable to fix them, as there seems reason to believe that these colours may change: where there is any such suspicion, comparisons should be multiplied, and their circumstances varied. As this is an interesting enquiry, and one suited to amateurs, I had intended to insert many more discrepancies between Smyth's colours and those of other observers; but I ultimately found that a very large proportion may be reasonably referred to the causes just mentioned, and included in the wide margin of those individual peculiarities of perception or judgment which astronomers term 'personal equation,' so that a few only have been retained, either where there may be some suspicion of real alteration, or as specimens of the differences to be expected in the enquiry. I have ventured to set aside, from their obvious peculiarity, Sestini's colours, which caused a re-examination by Smyth, published in his learned and elegant 'Ædes Hartwellianæ,' but I have inserted some of Dembowski's, as their usual agreement gives value to occasional discrepancies. The colours of all the objects in my list, as well as many others, were carefully compared with the Bedford Catalogue: my original instrument and experience were far inferior,* and my eye usually biassed by previous knowledge, so that I was little qualified for such a scrutiny; but with a great preponderance of agreement or acquiescence, a few discrepancies were noted: dates are added, as the idea of

* The subsequent great advantage of a 9-in. silvered mirror has been less apparent in this than in other respects. My experience concurs with that of Browning, who finds colour decrease with increasing aperture, so as to render stops serviceable, and of Huggins, to whom colour is imperceptible in too much or too little light.

periodical changes of tint involves no impossibility, and has been strongly advocated by Piazzi Smyth. The subject is a curious one, and it would be worth while to record from time to time the colours not only of associated but single stars as they may come under our notice. The *angles of position*, which measure the inclination to the meridian, of the line joining the stars, are given in degrees, with the first decimal. The following diagram, in which the direction of passage through



the field is indicated, will sufficiently explain the mode of measurement; the larger being always considered as the central star. The *distances* between the stars (always from centre to centre) are given from Smyth (or Struve for his own objects)

to fractions of a second up to $20''$; beyond that limit, to the nearest whole second.

After Binary and Double Stars are placed such Clusters and Nebulæ as are most conspicuous in a host of about 5,400. Many of the great wonders are of course beyond any common telescope: but the recent unprecedented extension of optical power at a moderate expense has induced me to add to my original list a considerable number of more difficult objects, especially pairs; and some as tests.

The Right Ascensions and Declinations have been brought up to 1870, by allowing for the Precession of the Equinoxes, which, by slowly carrying round the artificial network of meridians and parallels in front of the immovable heavens, is continually changing the *nominal places* (not the *relative positions*) of the stars. The nearest minute of time and space was thought a sufficient degree of accuracy in this computation. Globes and maps, admitting of no such reduction, will require mental allowance on this account in proportion to their date: in Proctor's Atlases the amount and direction of precession are indicated by arrows.

As to optical management: close pairs and crowded clusters gain by increasing the power; so *in general* do dissimilar colours, and very minute points near larger stars; but experience will be the best guide. For difficult pairs we should follow Herschel I.'s advice, and adjust the focus previously upon a single star of nearly the same altitude, size, and colour; the peculiar aspect of the double star will be afterwards more striking. Occasionally a slight change, especially lengthening, of focus may relieve a weary eye. In estimating colours, keep near the centre of the field: its edges may not be achromatic. Large nebulæ always require low powers; very small ones

must be more magnified to shew their nature, and resolvable ones, to insulate their sparkling points. In most cases low powers have the advantage from the beauty and variety of their broad fields. The magnifiers used by myself with $3\frac{7}{10}$ inches ranged from 64 to 250, in a few instances 300.

In the following list, under the head of Double Stars, the *Synonym*, which stands first, is either a Greek letter, which is Bayer's designation;—an Arabic numeral, which (unless otherwise specified) is Flamsteed's;—or a compound title referring to Piazzi's Catalogue, in which **P** indicates the observer's name, and the Roman numerals the hour of Right Ascension; *—to these are frequently added in parenthesis an Arabic numeral preceded by Σ (the conventional symbol for the name of Wilhelm Struve), which refers to the great Dorpat Catalogue of Double Stars; and many objects not in the Bedford Catalogue are designated solely in this way. In the class of Clusters and Nebulæ, the prefixed number is that in the General Catalogue of Sir J. Herschel (1864); to which is subjoined, either M, followed by a numeral referring to Messier's Catalogue of Nebulæ in the 'Connoissance des Temps' for 1783 and 1784; or ♅, the symbol of the name of Herschel I., the Roman numeral after which shews the class in the catalogues of that observer. After the Synonym comes the *Place in the Heavens*, given first in hours and minutes of Right Ascension, then in degrees and minutes of Declination, marked N or S, as the case may be; the Italic letters, *n* (north), *s* (south), *p*

* The student will hardly need to be reminded that Piazzi's numbers require the hour to be specified, and that as they merely express sequence in R.A. they give no intimation of the constellation in which the stars are to be found. They are taken from the Palermo Catalogue of 7,646 stars, published in 1814, the result of nearly 150,000 observations, and requiring 30,000,000 figures for their reduction.

(preceding), and *f* (following), being employed to indicate the relative positions of neighbouring objects. Next are placed (in the case of Double Stars,) the *Magnitudes* in corresponding Arabic numerals separated by a comma; the half magnitudes being expressed by the decimal point and figure ·5 (the magnitudes of other observers are carried to minuter divisions). Then follow the *Position-angles*, the *Distances*, and the *Colours*; with occasional remarks from other observers.

All data, not included by ( ), or [ ], or referred to other sources, are taken from the Bedford Catalogue or its revision in the Speculum Hartwellianum: for many descriptions of objects, and directions for finding them, the author is responsible.

Abbreviations and Symbols.—A. *Argelander*; D. *Dawes*; De. *Dembowski*; Fl. *Flamsteed*; H. *Herschel I.*; H. *Herschel II.*; Kn. *Knott*; M. *Messier*; P. *Piazzi*; P. Sm. *Piazzi Smyth*; Se. *Secchi*; Sm. *Smyth*; Σ. *Struve I.*; O Σ. *Struve II.*; est. *estimated*; c.p.m. *common proper motion*; var. *variable*.

ANDROMEDA.

THIS constellation is rich in interesting objects of every class; on the meridian, however, it is inconveniently high for an achromatic telescope, and should therefore be examined some hours E. or W. of it, like many other similarly situated regions.

Double Stars.

γ (Σ **205**). $1^h\ 56^m$, N 41° 42′: 3·5, 5·5: 61°·6: 11″: deep yellow, sea-green. One of the most beautiful pairs in the heavens, though probably stationary, and devoid of the interest

[ANDROMEDA]

of a binary system. It seems to have been first noticed by C. Mayer in 1778. In 1842 Σ found the companion double; so close that common telescopes will not even elongate it, though it has been done with 4¼ in. Cooke, and the finest only can divide it. This is said to have been effected with a 6 in. object-glass: 8 in. should be certain. Some of With's 6½ in. silvered glass specula will split it: those of 8½ in. are guaranteed to do so; but of course only in a favourable state of air. Strange discrepancy as to mags: OΣ giving 4, 5; Se 8·5, 9; yet variation has not been suggested. Murray, D, and Jacob have noticed difference in colour, yellow and blue, whence the combined impression, green. D 125°·5: 0″·4, 1842; Kn 107°·1: 0″·6, 1865. Evidently binary.*

μ. 0^h 50^m, N 37° 51′: 4, 16: 115°: 45″: white, dusky grey. Inserted as a light-test. 16 was seen but once in many trials by Sm, when μ was hidden by a bar. D, who rated it 11½ or at most 11¼ of Σ's scale, glimpsed it with a 4·8 in. aperture of 8 in. achr. even when his vision was slightly impaired. I held it pretty steadily in the presence of μ with 9⅓ in. spec. Buffham glimpsed it with 6½ in. ap. of 9 in. spec.

π. 0^h 30^m, N 33° 0′: 4·5, 9: 173°·9: 36″: white, blue.

56, P I 203. 1^h 48^m, N 36° 37′: 6, 6: 302°·4: 176″: yellow, 1834; Σ (4 App. I) *p* smaller and always deeper in colour, 1836; [*p* larger and ruddier, 1850; nearly equal, *p* redder, 9 in. spec. 1871]. A specimen of a class whose similarity, notwithstanding their distance, always gives the impres-

* In examining this and similar test-objects, it is important to note the difference between one long disc crossed by a dark interference-line which is sometimes supposed to be division, and two round discs with black sky between them.

sion of physical connection; more clearly deduced in this case from a 'proper motion' through space, common to both. Nearly pointed at by γ and β Triang. at about twice their distance.

36 (Σ **73**). o^h 48^m, N 22° 56′: 6, 7: 315°·7: 1″·1, 1835; Se 349°·5: 1″·3, 1866; De 350°·8: 1″·3, 1870: bright orange, yellow. Binary; widened into an easy as well as beautiful object. Closely *n p* η towards ζ: visible to naked eye.

59 (Σ **222**). 11^h 3^m, N 38° 26′: 6, 7·5: 34°·7: 16″·3: bluish white, 1835 [yellowish white, 1850, 1855], pale violet; Σ very white, 1831. [Not more than 1 m. difference, 1850, 1855, 1862, 1871 (9 in. spec.); Σ 6·7, 7·2.]

P II 61. 11^h 15^m, N 40° 49′: 7, 11: 355°: 50″: yellow, pale lilac. I failed to see the companion, 1851, but the object guides to a pretty open 8 m. pair, one of which is P II 62. Field fine with low power. About $\frac{1}{3}$ from γ towards Algol.

P O 175, 176 (Σ 1 App. I). o^h 39^m, N 30° 14′: 8, 8: 235°·8: 46″: pale yellow. Curious similarity. 1½° *f* δ.

22. o^h 4^m, N 45° 21′: 5: white, 1838 [clear yellow, 1850]. A guide to an elegant pair Σ **3**, nearly *n*, 8, 9: 84°: 4″·9: pale yellow, bluish.

P XXIII 240 (Σ **3048**). XXIII^h 51^m, N 23° 38′: 8·5, 9: 313°·9: 9″·4: pale white, yellowish, 1833; [1 mag. difference, 9 decidedly blue, 1850; 8, 10: blue? a 12 m. *comes*, 9 in. spec. 1871.]

(Σ **3050**. XXIII^h 53^m, N 33° 0′: 6, 6: 191°: 3″·8, 1832; De 199°·8: 3″·2, 1865: yellowish.)

[Σ **79**. o^h 53^m, N 44° 1′: 6, 7: 192°·4: 7″·6: very white, bluish; [7 greenish, 9 in. spec. 1871. Very beautiful.]

[ANDROMEDA]

[Σ **179**. I^{h} 46^{m}, N 36° 41′: 6·7, 7·7 : 160°·5 : 3″·4: white. Bird moving? 1871.]

(Σ **3042**. XXIII^{h} 45^{m}, N 37° 10′: 7, 7: 89°·3: 4″·2: very white.)

[ψ. XXIII^{h} 40^{m}, N 45° 43′: 5, 5: white. Of the same class with 56 and P I 203.]

[About $\frac{1}{3}$ from γ Androm. towards β Pers. a little *n* of the line is a curious group of 4 small stars, and $\frac{1}{2}$° *n*, a pair.]

[Red Star.* 0^{h} 13^{m}, N 43° 56′: 8·2 m. Krüger.]

(Red Star. 11^{h} 10^{m}, N 44° 34′: 9 m. H.)

Nebulæ.

116 (M 31). 0^{h} 36^{m}, N 40° 30′. One of the grandest in the heavens; long, oval or irregularly triangular, ill-bounded, and brightening to the centre; so plain to the naked eye that it is strange that the ancients scarcely mention it. By moving the telescope rapidly to gain contrast Bond extended it to the surprising dimensions of 4° in length and $2\frac{1}{2}$° in breadth, of which common instruments shew little, and less in proportion to the increase of power. No telescope has been able to deal with its nature; Bond's giant achromatic found no resolution, though it was seen through a rich stratum containing above 1,500 stars. It detected, however, two curious dark streaks, like narrow clefts, both far beyond any ordinary instruments, in which the darker of them forms in reality the boundary of the strongest light on one side: both are well seen by Se: I have

* The catalogue of these singular and beautiful objects compiled by Schjellerup can only be regarded as provisional; and his Nos. have therefore not been employed. It is now undergoing careful revision by Birmingham.

[ANDROMEDA]

caught one, though with much difficulty, with $5\frac{1}{2}$ in. achr. 1863, and traced both through a long extent with 8 in. silvered glass (With), 1864; but this was *after the knowledge of the fact*, which has a great influence upon the eye; the truth of H.'s remark being often exemplified, that a less degree of optical power will *shew* an object than would be requisite for its *discovery*. Huggins finds a continuous spectrum, but cut off at the red end. It seems, therefore, not gaseous: if stellar, it is strange that, comprising such extremes of feebleness and condensation, it can be resolved with certainty nowhere, the nucleus only shewing a granular texture in great instruments. There is some deep mystery here.

117 (M 32) is in the same field with a low power; a small, bright object, resolved into stars by the E. of Rosse's 3 f. speculum and Buffham's 9 in. (With). Spectrum like that of M 31.

105 (H V 18). $0^h\ 33^m$, N 40° 59′. Large faint oval neb. requiring low power; resolved by Bond: a large field (my 64 was barely large enough) includes it with 116 and 117.

[4964 (H IV 18). XXIII^h 20^m, N 41° 46′. Small, but very bright. Lassell sees nucleus and two oval rings: E. of Rosse, a spiral structure. My 9 in. spec. shews bluish soft disc with woolly border and suspicion of dark centre. Huggins, 8 in. achr. annular, greenish blue; spectrum of 4 gaseous lines;—nitrogen, hydrogen? To find it, sweep 23^m E from *o*, 4 mag.]

[218. $1^h\ 2^m$, N 35° 1′. Rather faint; but easy with $9\frac{1}{3}$ in. spec. *n p* β, 2 m. strong yellow, in the same field.]

ANSER.

This little modern asterism, which is numbered as part of Vulpecula, does not contribute much of general interest to the Bedford Catalogue; but the two following fields will give pleasure to all who seek out the glories of creation.

[6, 8. XIX^h 23^m, N 24° 24′: 4, 5: deep and pale yellow. In a beautiful field, 3° nearly *s* from β Cyg.]

[4, 5, 7, &c. XIX^h 20^m, N 19° 33′. A magnificent region.]

ANTINOUS.

A constellation now usually thrown into Aquila, containing some bright stars, of which η (XIX^h 45^m, N 0° 38′) is variable, according to A, in about 7^d 4^h 14^m; increasing in 57^h, but occupying 115^h in its decrease. Such inequalities are frequently met with among these mysterious objects.

Double Stars.

P XX 26 (Σ **2644**). XX^h 6^m, N 0° 29′: 6·5,7: 207°·9: 3″·5: white, 1832; De 7, 7·2; white, green, 1853–4; Se 7, 7·2; white, bluish, 1855; [nearly equal, 1850, *n* a little larger with power 144; 8·3, 8·6, 9 in. spec. 1871.] Se Kn slow angular movement. 2° *n* of θ, a little *f*.

P XVIII 197. XVIII^h 43^m, S 6° 3′: 7, 9: 168°·9: 99″: orange, cerulean blue. A smaller closer pair *s p* [white, blue]. Field beautiful with 80. 64 includes the cluster M 11.

P XX 140, 139. XX^h 21^m, S 2° 32′: 7·5, 8: 191°: 60″: white, 1833 [white, grey, 1850, 1855]. Each has a faint companion. Field, if large, very fine.

P XX 116 (Σ **2677**). XX^h 18^m, N 0° 39′: 7·5, 12: 28°: 30″: white, grey. Sm says the companion is 'so minute that

its distance is only an estimation.' I saw it steadily with $3\frac{7}{10}$ in. a good test; an isos. triangle with θ Antin. and 69 Aquil. the *s* of two 7 m. stars; the other, PXX 117, a fine orange.

P XX 12. $\text{xx}^h\ 5^m$, S 0° 31′: 8, 9: 202°·2: 54″: pale grey, 1835 [yellowish, bluish, 1850, 9 in. spec. 1871]. 1° *n* of θ.

P XVIII 274, 275 (Σ **2434**). $\text{xviii}^h\ 56^m$, S 0° 53′: 9, 9: 146°·8: 26″, 1838; De 136°·8: 24″·3, 1864: white. [*s f* considerably the smaller, 1850, 1871.] A 16 m. (Σ 10·3 m) star at 2″ seems moving: I have not seen it. Burnham easy with 6 in. achr.

(37. $\text{XIX}^h\ 28^m$, S 10° 50^m: 5·5, has within about 1° *f*, 30′ *n*, 1 double and 2 triples, Σ **2541**, Σ **2545**, Σ **2547**, and a star with minute double *comes n p* Σ **2545**).

[Σ **2654**. $\text{xx}^h\ 8^m$, S 3° 54′: 6·2, 7·7, 1826 [8, 9, 1855]: 233°·9: 13″·9: white [yellow? blue?]

[Σ **2661**. $\text{xx}^h\ 13^m$, S 2° 39′: 7·5, 8·7: 342°·4: 24″: white, greyish.]

[Triple. 26, $\text{XIX}^h\ 14^m$, S 5°39′, 5 m. (A) is a guide to a delicate and very beautiful triple star $2^m\ 25^s$ (or 36′ of arc) E: 7·5: orange, with 2 blue companions, 11, 12, close together *n* a little *p*.]

Cluster.

4437 (M 11). $\text{xviii}^h\ 44^m$, S 6° 25′. Fine cl. like an expanded fan, at the upper edge of the luminous cloud, which marks the Shield of Sobieski. Sm compares it to a flight of wild ducks. H stars 11 m. divided into 5 or 6 groups [noted independently with $5\frac{1}{2}$ in]. An 8 m. star is a little within its apex; an open 8 m. pair *s f* beyond it. Se perceives it unaided in the Italian sky.

AQUARIUS.

A dull-looking constellation, but well repaying telescopic research.

Double Stars.

ζ (Σ **2909**). XXII^h 22^m, S 0° 41′: 4, 4·5: 356°: 3″·6, 1831; 346°·9: 3″·2, 1852; D 336°·3: 3″·3, 1866; Kn 333°·6: 3″·3, 1871: flushed white, creamy. A very fine object; two suns revolving, Sm thinks, in a period of 750 y., but as yet very uncertain. A very small aperture shews it. In the centre of a triangle of nearly equal stars, all easily seen with the naked eye.

12 (Σ **2745**). XX^h 57^m, S 6° 20′: 5·5, 8·5: 191°: 2″·8: creamy white, light blue. Slow motion? Brightest of vicinity.

ψ^1 (Σ 12 App. II). XXIII^h 9^m, S 9° 48′: 5·5, 9: 310°·5: 49″·5: orange or topaz yellow, sky blue. Σ suspects c. p. m.

107. XXIII^h 39^m, S 19° 24: 6, 7·5: 141°·8: 5″·5: white, purplish. P Sm thinks colours variable. Possibly binary.

29. XXI^h 55^m, S 17° 35′: 6, 8, 1830: 242°: 4″·5: white, bluish. [Very little differing in size, 8 perhaps the smaller, 1849, 1851–3–5; 0·3 mag. smaller, 9 in. spec. 1871.]

41. XXII^h 7^m, S 21° 43′: 6, 8·5: 119°·4: 4″·8: topaz yellow, cerulean blue. A 7 m. star makes it a pretty group.

94 (Σ **2998**). XXIII^h 12^m, S 14° 10′; 6, 8·5: 345°·4: 14″: pale rose, light emerald, 1838; orange, flushed blue, 1850. Σ ascribes c. p. m. to this beautiful pair.

53. XXII^h 19^m, S 17° 24′: 6·5, 6·5: 301°·5: 9″·9: pale white.

P XXII 200 (Σ **2935**). XXII^h 36^m, S 8° 59′: 7, 8·5: 313°·8: 2″·7: white, 1833, 1838 [8·5 grey or bluish? 1850]; so Se 1855. 2½° p λ, a little s.

[AQUARIUS]

P XXII 219 (Σ **2944**). Triple. xxII^h 41^m, S 4° 54′: 7·5, 8, 9: 247°·4, 158°: 4″·2, 55,″ 1835; De 146°·7: 50″·7, 1862: yellow, two flushed white.

[Σ **2913**. xxII^h 24^m, S 8° 47′: 7, 8: 331°·9: 8″: white, reddish. [9, 10 of Sm's scale, 9 in. spec. 1871.]

[τ^2. xxII^h 43^m, S 14° 17′, is a beautiful orange 5 m. star, with distant companion.]

[24—*f* M 2, a little *n*, in the head; 7, 10.]

[About half-way between β Aquar. and ε Peg. lies a pretty little white 8·5 m. pair.]

[About xxI^h 38^m, S 0° 30′ a rich region where a low power includes three double stars at once.]

Nebulæ.

4678 (M 2). xxI^h 27^m, S 1° 24′. Beautiful large round neb. shewing, with $3\frac{7}{10}$ in. aperture, a granulated appearance, the precursor of resolution. H compares it to a heap of fine sand, and considers it to be composed of thousands of 15 m. stars. Sm observes that 'this magnificent ball of stars condenses to the centre, and presents so fine a spherical form that imagination cannot but picture the inconceivable brilliance of their visible heavens, to its animated myriads.'

4628 (♅ IV 1). xx^h 57^m, S 11° 52′. Planetary; somewhat elliptic; very bright for an object of this nature; pale blue; not well defined in $5\frac{1}{2}$ f. achr., but bearing magnifying like a planet, much otherwise than a common nebula. One of the finest specimens of these extraordinary bodies, to which their discoverer ♅ assigned a distinct class. The E. of Rosse finds a ray on each side. Lassell detects within it a bright well-defined elliptic ring; Buffham, 9 in. spec., an opening.

[AQUARIUS]

Se, who gives its diameters 25″ and 17″, saw it sparkle, and believed it to be a heap of stars: the spectroscope of Huggins reveals, however, the astounding fact that it is a mass of incandescent gas. About $1\frac{1}{3}°$ *p* ν, 5 m.

AQUILA.

Al Tair (XIX^h 44^m, N 8° 32′), the *lucida* of this rich constellation, has been thought variable, and has a very sensible proper motion.

Double Stars.

γ. XIX^h 40^m, N 10° 18′ : 3 : very fine yellow. Not inserted for Sm's 12 m. attendant, but for the sake of its beautiful field with a curious doubly-curved row of stars a little *s*. 3′ *s* Burnham points out a pair 10 or 11 m : est. 40° : 3″ : a 3rd star 20″ *p*. It is now brighter than β, which implies a change in one of the stars; though in many instances Bayer, who affixed the Greek letters in 1603, seems not to have been entirely influenced by magnitude. β, according to OΣ, is carrying with it through space a very minute companion, 11–12 m. 12″ distant; annual progress nearly 0″·5, yet no orbital motion detected. δ (most delicately triple) is in a beautiful neighbourhood.

π (Σ **2583**). XIX^h 43^m, N 11° 28′: 6, 7 : 121°·3 : 1″·7, 1836; Kn 1″·5, 1865; pale white, greenish, 1831, 1836; Σ yellowish, 1829; Se yellow, blue, 1855; De both white, 1856. Se in slow motion. [Not single with 80, very close with 144; a good test. $5\frac{1}{2}$ in. shewed a 14 m. star *n p*.]

15. XVIII^h 58^m, S 4° 13′: 6, 7·5 : 206°·6 : 35″ : white or yellowish white, red lilac. 1° nearly *n* from λ Antin.

[AQUILA]

23 (Σ **2492**). XIX^h 12^m, N 0° 51′: 6, 10: 12°·6: 3″·1: light orange, grey. H and Sm notice the increasing visibility of 10 with higher powers, which struck me independently. I had not perceived it with 80; it was distinctly seen with 144, possibly from some peculiar quality in its light. An elegant object, but requiring fine weather; easily found from δ and ν.

57 (Σ **2594**). XIX^h 48^m, S 8° 34′: 6·5, 7: 171°·5: 35″: blue, 1834; Σ very white, 1835; [distinctly contrasted, 1851; pale yellow, pale lilac, 'colours entirely different,' 1855; a totally independent observation, as I had not identified the object; pale yellow, bluish or greenish, certainly unlike, 9 in. spec. 1871; Whitley bright white, reddish white, 1868; Kn white, very pale blue, 1871. This pair should be watched, as two of the first observers have attested the similarity of the colours.]

5 (Σ **2379**). Triple. XVIII^h 40^m, S 1° 6′: 7, 8, 14: 121°·5, 145°: 13″·3, 30″: white, lilac, blue. 14 is so minute, Sm says, as to have escaped former observers except H. P however saw it with far inferior means; and I have on several occasions, from 1850 to 1852, seen it more or less distinctly by averted vision, though 14 m. was usually far beyond my reach: it rather improves with magnifying: very minute, 9 in. spec. 1871. 5 is η Serp. of some maps.

11 (Σ **2424**). XVIII^h 53^m, N 13° 27′: 7, 10: 240°·9: 19″·1: pale white, smalt blue. Sm thought 7 might have been rated 6. Σ 5·7; De 5. It lies equilaterally with ε and ζ. [A pretty 10 m. pair *f* a little *n*: another, about 38′ *s*, 14′ *f* is Σ **2426**, 6·8, 8·2: 259°: 16″·7: reddish yellow, grey. Bird finds angle reversed.]

P XX 2 (Σ **2634**). XX^h 3^m, N 16° 32′: 7, 10: 13°·2: 5″·9:

[AQUILA]

pale topaz, lucid blue. H red, deeper red; but he was partial to red tints. I thought 7 white, 1850. Close to Sagitta.

P XIX 144 (Σ **2532**). XIX^h 24^m, N 2° 38′: 7, 11, 1838: 4°·9: 37″: deep yellow, pale green. [11 readily visible 1850, 1855, even considerably out of focus, and several hours past meridian, as if 10 m.; the colour also, previously known, was evident; Kn 11–12, 1871. 1° *f* δ, furthest of two *f* that star. A pretty pair, very unequal, *n p*.]

P XIX 307 (Σ **2590**). XIX^h 46^m, N 10° 2′: 7, 13: 307°·8: 15″: lucid white [so 1864; pale orange, 1865], blue. Light-test for moderate apertures. Minute pair *p*, a little *s*. Just *f* ο, 5 m. 1½° *n* of α.

P XVIII 302 (Σ **2446**). XVIII^h 59^m, N 6° 21′: 7·5, 9: 153°·9: 10″·3: lucid white, cerulean blue. Brightest in the vicinity.

P XIX 241 (Σ **2562**). XIX^h 36^m, N 8° 4′: 7·5, 9·5, 1833: 253°·7: 27″: pale topaz, lilac. [9·5 larger? 1850. P rated it 10. Several minute points near, 9 in. spec. Equilateral with α and γ. 1° *p* lies a pretty pair, 9·5, 11: and again, not far *s p*, a very fine field.]

P XIX 257 (Σ **2570**). XIX^h 39^m, N 10° 28′: 8, 10: 276°·5: 4″: white, smalt blue. Closely *n p* γ. A pretty group a little *n*.

P XX 43, 44. XX^h 8^m, N 6° 11′: 8·5, 8·5, 1833: 11°·7: 44″: lucid white. [*s* star the smaller, 1850; reverse of Sm; white, blue, 1871; Kn both white: *s* the less, 1871.]

P XVIII 263 (Σ **2428**). XVIII^h 54^m, N 14° 44′: 8·5, 10·5: 289°·1: 6″·5: pale yellow, 1836 [white, 1850], sapphire blue. 'Handsome test-object,' Sm. [10·5 occasionally distinct, though long past meridian, 1850; 12 m. 1871. 10′ *s* very little *f* ε, 3m. a beautiful yellow star. A fine field.]

[AQUILA]

P XIX 250 (Σ 2567). XIX^h 38^m, N 12° 4′: 8·5, 14, 1838: 312°: 20″: white, blue. [14 must be var; Σ 9·5, 1829: Kn 10·2, 1862; [much larger than 10 of P XIX 257, 1865.]

[About $\frac{1}{3}$ from ζ Aquil. towards α and β Sagittæ are two 6 m. stars (Bode 67,71), near together, visible to the naked eye: the *n p* of these is a fine wide pair: 6, 8: yellow, pale lilac.]

12, 6 m. *s p* λ, 3 m. has a 12 m. *comes* est. 100°: 25″. Birmingham.

[10, 6 m, closely *n p* 11, stands between 2 curious groups.]

[68, XX^h 22^m, S 3° 47′: 7 m. is one of a pretty triangle: a little *s p* 69, 5 m.]

[About XX^h 28^m, N 1° lies a triangle, the most *s* of which is a wide pair: 7, 9 or 10: orange, blue. All the Galaxy in Aquila is strewed with pairs and groups of stars.]

[Red Star. XVIII^h 57^m, S 5° 53′: 7·3 m; 40′ *f* 12, 6 m. Fine specimen; colour discovered by Kn 1861. About 7^m *p*, 5′ *n* is a 5 m. star, yellow, a pointer to a fine blue star 8 m, 20′ *s p*.]

Cluster.

4451 (H 2024). XVIII^h 50^m, N 10° 11′. Interesting field.

ARGO NAVIS.

Not a remarkable constellation, excepting for the crowded part of the Galaxy which it includes.

Double Stars.

P VII 149, 147. VII^h 29^m, S 23° 11′: 6, 6: 284°·1: 10″·2: topaz-tinted. [*n p* rather larger, 1851, 1856; reverse of Sm 1831.]

P VIII 72, 74. VIII^h 19^m, S 23° 38′: 6, 9·5: 85°·4: 45″: orange, bluish green.

[ARGO NAVIS]

P VII 175, 177. VII^h 34^m, S 26° 30′: 6·5, 6·5: 326°·8: 9″·8: topaz yellow. [Both stars much larger, 1851, than P VII 149, 147, as if the mags. had been accidentally reversed.]

2 (Σ **1138**). VII^h 40^m, S 14° 23′: 7, 7·5: 338°·8: 16″·8: silvery white, pale white. In field with 4, 5 m. pale yellow.

5 (Σ **1146**). VII^h 42^m, S 11° 53′: 7·5, 9: 19°: 3″·5: pale yellow, light blue, 1834; Σ 5·3, 7·4, 1831. [9 ruddy? 1851.]

[About 1½° *s* of 2 a wide 7 m. pair, deep orange, has a binary aspect; 5½ in. 1864.]

Clusters and Nebulæ.

1551 (H VIII 38). VII^h 31^m, S 14° 12′. Grand broad group, visible to naked eye, too large even for 64: some brilliant 5 or 6 m. stars, and neat pair, 7·5, 8: 303°·8: 8″: bright bluish white. About 2½° *p* a group round 4. A fiery 5 m. leads the region.

1564 (M 46). VII^h 36^m, S 14° 31′. Beautiful circular cloud of small stars (H 10 m.), about ½° in diam.: best with low power: a little *p* the group round 4, nearer to it than 1551. 1565, a faint planetary neb. on its N. verge, is in Lassell's 20 f. reflector 'an astonishing and interesting object;' he and E. of Rosse see it annular: so Buffham, 9 in. 'With.'

1571 (M 93). VII^h 39^m, S 23° 33′. Bright cl. in a rich neighbourhood. H 8–13 mag.

1630 (H VII 11). VIII^h 5^m, S 12° 29′. Large loose cl. of stars, chiefly about 10 m., closely *n p* 19 Arg., a 6 m. yellow [bright orange] star, attended by a fine group. 19 seems larger than 6 m. to my unaided eye.

1611 (H VI 37). VII^h 54^m, S 10° 25′. Fine broad starry cloud, from 10 m. down to mere nebulosity; much better with 64 than higher powers. Vicinity gorgeous.

[ARGO NAVIS]

1567 (H IV 64). $\text{VII}^h\ 36^m$, S 17° 54′. Plan. neb. bright; pale bluish white; H 12″ or 15″ diam. With my 64, like a dull 8 m. star: with more power, small, brilliant, undefined, surrounded with a little very faint haziness. In a glorious neighbourhood.

ARIES.

Three stars near together mark it to the naked eye, but it reaches some way further E. into a dull region.

Double Stars.

γ (Σ **180**). $\text{I}^h\ 46^m$, N 18° 40′: 4·5, 5: 359°·8: 8″·8: bright white, pale grey or faint blue; some disagreement as to the colours. Discovered by Hooke in following the comet of 1644. 'I took notice that it consisted of two small stars very near together; a like instance to which I have not else met with in all the heaven.' Good object for small telescopes.

ε (Σ **333**). $\text{II}^h\ 52^m$, N 20° 49′: 5, 6·5: 193°·5: 0″·5, 1835; Kn 198° 4: 1″, 1866; De 197°·8: 1″·1, 1868: pale yellow, whitish. Seen by Buffham with 4½ in. 'With' mirror, 1869. Σ vars? Binary.

π (Σ **311**). Triple. $\text{II}^h\ 42^m$, N 16° 55″: 5, 8·5, 11: 121°·6, 109°·9: 3″·1, 25″: pale yellow, flushed, dusky. H 11 brighter than 8·5, 1782. [*Comites* not seen, 1855; 9·5, 13, 9 in. 1871.]

λ. $\text{I}^h\ 51^m$, N 22° 58′: 5·5, 8: 45°·6: 37″: yellowish white, blue, 1830; Whitley 8 reddish lilac, 1868. Pointed at by γ and β.

14. Triple. $\text{II}^h\ 2^m$, N 25° 20′: 5·5, 10·5, 9: 43°·5, 278°·6: 82″·6, 106″·5: white, blue, lilac [a very fine colour]. Birmingham adds another *comes*, smaller and more distant.

[ARIES]

30, P II 128 (Σ 5 App. I). 11^h 29^m, N 24° 5′: 6, 7: 273°: 38″: topaz yellow, pale grey. 'The most southern of a group of about a dozen double stars, spread over the adjoining portions of the three constellations, Aries, Musca, and Triang. with extensive patches of dark and blank space between them.' Sm.

P I 179 (Σ **174**—Fl 1). 1^h 43^m, N 21° 38′: 6, 8: 169°·9: 2″·4: topaz yellow, smalt blue, 1836. De white, 1854. 80 just divides this beautiful pair. 2° *n p β*.

33 (Σ **289**). 11^h 33^m, N 26° 30′: 6, 9: 0°·2: 28″·5: pale topaz, light blue. [9 seems very small, 1850.] In Musca.

52 (Σ **346**). Quadruple. 11^h 58^m, N 24° 45′: 6·5, 7, 15, 13: 265°·7, 1835; Kn 268°·9, 1865; 355°, 85°; 0″·8, 5″, 105″: bright white, pale blue, blue, lilac. 'Most difficult.' [6·5 notched, 5½ in. power 450, 1861.] Matthews sees 15, 4½ in. achr.

10 (Σ **208**). 1^h 56^m, N 25° 19′: 6·5, 8·5: 26°·8: 2″·2, 1838: De 33°·9: 1″·4, 1863: yellow, pale grey. Birmingham sees a triple star in field *s f*. Between *α* Ariet. and *α* Tri. nearest former.

AURIGA.

The leader of this beautiful constellation, Capella (v^h 7^m, N 45° 52′), is very brilliant. H and Σ think it has increased. H classed it decidedly above Wega in 1847, otherwise than he had formerly, and therefore second in the heavens. So Galle and Heis. With me, Wega takes precedence; but the objects are distant, and differ in colour,* white and sapphire, and, as

* The Astrophotometer of Berthon, a beautiful apparatus, not yet executed, would place them side by side in the field.

[AURIGA]

Sm. observes, this difference may influence estimates of size. Ptolemy, El Fergani (10th cent.), and Riccioli, have all called Capella *red*. Its parallax is almost imperceptible, proving amazing distance, far exceeding that of some smaller stars. Such instances shew the insecure foundation of H's theory as to the regular distribution of stars in space. See M 37 *infra*.

Double Stars.

14 (Σ **653**). v^h 7^m, N 32° 32′ : 5, 7·5 : 224°·5 : 13″·5 : pale yellow, orange, 1832; greenish yellow, bluish yellow, 1850; Σ pale green, bluish white, 1830 [pale yellow, lilac, 1850]. Σ triple; 11 : 342°·4 : 12″·6, 1830.

26 (Σ **753**). v^h 30^m, N 30° 25′ : 5, 8 : 267°·8 : 12″·3 : dusky white, pale blue. 3° *n f* β Tauri. Triple, 12 m. est. 115° : 30″. Burnham.

ω (Σ **616**). IV^h 50^m, N 37° 42′ : 5, 9 : 352°·6 : 7″ : flushed white, light blue, 1831, 1833, 1850; Σ pale green, bluish white, 1828 [white, ruddy, 1850; an unusual combination, plainer with 80 than 250.] 4 of A and Proctor. Fl both symbols.

56. VI^h 37^m, N 43° 42′ : 6, 8·5 : 57″ : 17°·1 : silvery white, lilac.

41 (Σ **845**). VI^h 2^m, N 48° 44′ : 7, 7·5 : 352°·8 : 8″·2 : silvery white, pale violet. Relatively fixed, common proper motion: a significant and not infrequent phænomenon.

P V 225 (Σ **796**). v^h 42^m, N 31° 45′ : 8, 8·5 : 61°·5 : 3″·8 : creamy white, pale grey.

(16. v^h 10^m, N 33° 14′ : 5, 11 : 50° ± : 4″·3.—103 of O Σ's Poulkova Catalogue.)

[Σ **872**. VI^h 7^m, N 36° 11′ : 6, 7 : 217°·4 : 11″ : white; [pale yellow, pale lilac, 1872.]

[AURIGA]

(Σ **572**. IV^h 30^m, N 26° 41′: 6·5, 6·5 (vars.): 210°·3: 3″·2: yellowish.—*Bode* 4.)

(Σ **644**. V^h 2^m, N 37° 8′: 6·7, 7: 219°·2: 1″·6: golden, reddish blue; remarkable and constant colours.)—*p* is a cl. 996 (H VIII 61).

[Σ **941**. VI^h 29^m, N 41° 41′: 7, 8: 77°·6: 1″·9: bluish white, purplish white. A good test; the *n* star of two in finder, 1° *s* of 50 Aur., 5 m.]

[Σ **718**. V^h 22^m, N 49° 22′: 7·2, 7·2: 74°·2: 7″·8: very white.]

[ϕ. V^h 19^m, N 34° 22′, 5 m., lies in a superb region.]

(Red stars. IV^h 37^m, N 32° 41′: 8·5 m.—IV^h 43^m, N 28° 18′: 8 m.—V^h 12^m, N 34° 8′: 8 m.—VI^h 5^m, N 27° 12′: 8·5 m.—VI^h 28^m, N 38° 34′: 6·5 m.—all H.)

Clusters.

1119 (M 38). V^h 21^m, N 35° 47′. Noble cl. arranged as an oblique cross; pair of larger stars in each arm; brighter single star in centre; [not brighter than those pairs, 1871. Larger stars dot it prettily with open doubles. Glorious neighbourhood.]

1166 (M 36). V^h 28^m, N 34° 3′. Beautiful assemblage of stars, 8—14 m., very regularly arranged. 2° *f* φ.

1295 (M 37). V^h 44^m, N 32° 31′. Sm calls this 'a magnificent object: the whole field being strewed, as it were, with sparkling gold-dust; and the group is resolvable into about 500 stars, from 10 to 14 mags., besides the outliers.' Even in smaller instruments extremely beautiful, one of the finest of its class. Gaze at it well and long. Kn notices a brighter star near centre. All the stars in this mass must be nearly at

[AURIGA]

the same distance from us, and consequently their real sizes must be different. The aspect of the Nubecula Major in the S. hemisphere convinced H of this: it is ocular proof of the fact—deducible from parallax and common proper motion, yet long discredited—that, among the stars, apparent magnitude, and distance from the Earth, are quite unconnected.

1067 (♅ VII 33). $v^h\ 11^m$, N 39° 12′. Splendid region.

BOÖTES.

A fine constellation, of which the leader, Arcturus ($xiv^h\ 10^m$, N 19° 52′), is placed next to Sirius, and before Wega, by ♅ and H: Seidel gives Wega precedence. Fletcher has rated it alternately above and below Capella. A noble object at all times, but never so interesting as when, enveloped in the tail of Donati's comet, 1858, Oct. 5, and only 20′ from the nucleus, it flashed out so vividly its superiority. Sm calls it reddish yellow; it is golden yellow to me: Schmidt thought it had of late years lost all redness, and was growing paler. The first star seen in daytime, by Morin, 1635: it is stated, however, that Galileo saw stars by day. Schmidt has seen it *with the naked eye* 24 m. before sunset!* Arcturus has a great annual proper motion of more than 1″ RA, and nearly 2″ Dec.: so that, as Humboldt says, it has moved 2½ times the Moon's diam. since the days of Hipparchus. Yet its parallax is almost insensible. How inconceivable, then, must be its dimensions and its speed! Besides this motion, Huggins finds with the spec-

* Stone, with the 12¾ in. Greenwich object glass, finds its heating power perceptible, and considerably greater than that of Wega, which however can be detected. Huggins gives its heat equal to that of Regulus, and ½ greater than that of Sirius; Castor shewing none.

[BOÖTES]

troscope attached to his 15 in. achr. that it is approaching us at the rate of 55 miles per second! Boötes is rich in pairs, poor in clusters and nebulæ.

Double Stars.

ϵ (Σ **1877**). XIV^h 39^m, N 27° 37′: 3, 7: 321°·2, 2″·9, 1838; Kn 324°: 2″·7, 1867: pale orange, sea-green. Se 'most beautiful yellow, superb blue.' This 'lovely object,' as Sm calls it, is probably binary of long period: a well-known test for moderate telescopes. I have seen it perfectly with 2¼ in aperture (Bardou, Paris). 80 would divide it with 3$\frac{7}{10}$ in.

ζ (Σ **1865**). XIV^h 35^m, N 14° 17′: 3·5, 4·5: 127°·3: 1″·2, 1842; De 303°·2: 1″, 1864: bright white, bluish white. Σ alternately var: so Se, who also finds very slow motion. Probably closing. Excellent test: elongated, or in contact, 3$\frac{7}{10}$ in. 144, 250, 1854; wide, 9⅓ in. spec. 450, 1869.

π (Σ **1864**). XIV^h 35^m, N 16° 59′: 3·5, 6: 99°·3, 1836; Romberg, 101°·8, 1863: 6″: white, 1836; white, creamy, 1850: several observers see a slight difference.

ξ (Σ **1888**). XIV^h 45^m, N 19° 39′: 3·5, 6·5: 332°·1: 7″·3, 1831; Talmage, 298°·5: 5″·1, 1866; De 292°·7: 5″, 1870: deep yellow, flushed purple, 1857; De yellow, orange, 1856. Binary; H per. 117 y. Hind, 169 y.—Beautiful pair, 1^m *f*, 23′*s*: 8, 10: est. 180°: 1″. Burnham.

δ (Σ 27 App. I). XV^h 10^m, N 33° 48′: 3·5, 8·5: 75°: 110″: yellow, lilac.

μ^1 (Σ 28 App. I). XV^h 20^m, N 37° 50′: 4, 8: 171°·8: 109″: yellowish, greenish white; Whitley 8 lilac.—The companion, μ^2 (Σ **1938**): 8, 8·5: is very closely double; Σ 327°: 1″·4, 1826; D 190°·1: 0″·48, 1865; Kn est. 150°:

[BOÖTES]

0″·5, 1872; [elong. 5½ in., 1864]; divided with 8½ in. silv. specula, With. Binary; period doubtful. Hind, 314 y: probably all one system, as Σ finds c. p. m.

ι (Σ 26 App. I). XIVʰ 12′, N 51° 58′: 4·5, 8: 33°·4: 38″: light yellow, dusky white. Σ thought c. p. m. and found 4·5 double; extremely close, 0″·3.

44 (Σ **1909**). XVʰ 0ᵐ, N 48° 10′: 5, 6: 233°·8: 2″·9, 1830; Fletcher 240°·1: 4″·6, 1865; De 239°·8: 4″·8, 1868: pale white, lucid grey, 1842; yellow, cerulean blue, 1850; Σ pale white, pale blue, 1832; Fletcher white, yellow, 1851; Miller white, 1853; De yellow, orange, 1856; [yellow, ruddy or purplish, 1850.] Σ and A have found variable light here. Certainly binary; widening; but period unknown [wider than the following, 1850].

39 (Σ **1890**). XIVʰ 45ᵐ, N 49° 15′: 5·5, 6·5: 44°·7: 3″·8: white, lilac [scarcely 1 m. diff. 1850]. Se 6, 6·5, 1856; 6, 6·2, 1857. A little *n p* 44.

κ (Σ **1821**). XIVʰ 9ᵐ, N 52° 24′: 5·5, 8: 238°·1: 12″·7: pale white, bluish.

P XIV 69 (Σ **1835**). XIVʰ 17ᵐ, N 9° 2′: 6, 7·5: 186°·2: 6″·3: flushed white, smalt blue, 1835; De golden yellow, rose tint, 1853, 1855; [6 pale yellow; 7·5 sometimes blue, more usually tawny, 1854; 9 in. spec. 1872. This uncertainty of hue, which I have found troublesome in the smaller components of some pairs, may probably arise from contrast with the tinted back-ground given by the 'outstanding' blue rays in the light of the larger star, combined with unequal sensitiveness to colour in different states of the eye, which may sometimes be more impressed with the real, sometimes with the complementary, hue.]

[BOÖTES]

1 (Σ **1772**). XIII^h 34^m, N 20° 37′: 6, 10: 147°·1: 4″·9: sapphire blue, smalt blue. P XIII 161, 7 m. bluish, in field.

P XIV 279 (Σ **1910**). XV^h 1^m, N 9° 43′: 7·5, 7·5: 209°·7: 4″: pale white.

P XIII 220, 219. XIII^h 44^m, N 21° 55′: 7·5, 8: 208°·5: 86″: flushed white, 1831. [Some difference in colour, 1852, 9 in. spec. 1872, yellowish, bluish white? but very little in magnitude, each about 7; 220 rather the larger. 6, a fine yellow 5 m. star in field.]

[Σ **1850**. XIV^h 23^m, N 28° 52′: 6·1, 6·7: 262°·2: 26″: very white, 1833. [pale yellow, pale blue, 9 in. spec. 1872.]

[Σ **1919**. XV^h 7^m, N 19° 46′: 6·1, 7: 10°·2: 25″: yellowish white, white.]

[Σ **1884**. XIV^h 43^m, N 24° 54′: 6·2, 7·8: 52°·2: 1″·2: yellowish, bluish.]

[Σ **1825**. XIV^h 11^m, N 20° 44′: 6·8, 8·5: 185°·7: 3″·4, 1830; De 178°·8: 3″·9, 1864: 6·8 white. *f a*, 1° *n*.]

[Σ **1883**. XIV^h 42^m, N 6° 30′: 7, 7, *p* smaller: 272°: 1″·2: yellowish. A solitary object, Bird.]

[Σ **1793**. XIII^h 53^m, N 26° 27′: 7, 8: 242°·3: 4″·4: white, bluish.]

[Σ **1785**. XIII^h 43^m, N 27° 38′: 7·2, 7·5: 164°·4: 3″·5: white, 1830; De 192°·4: 2″·6, 1864; Kn 199°·2: 2″·5: very pale yellow, bluish, 1871; [yellow, lighter yellow? 9 in. spec. 1871.] Binary.

[Σ **1873**. XIV^h 38^m, N 8° 15′: 7·8, 8·3: 94°·4: 6″·3, very white [yellowish, bluish, 1871.]

[About XV^h, N 54° is a fine open pair, pale blue? grey? just visible to naked eye.]

[BOÖTES]

Nebula.

(4029 (H II 756). xiv^h 55^m, N 54° 24′. Faint: a guide to a pair *f*, from which a straight line of smaller stars extends.)

CAMELOPARDUS.

Wide-spread, but obscure; containing many good objects.

Double Stars.

2 (Σ **566**). iv^h 30^m, N 53° 13′: 5·5, 7·5: 308°·7, 1836; De 299°·5, 1863: 1″·7: yellow, pale blue; 'an exquisite object' [not seen]. Pair *f* in field, De 9·5, 10: 47°: 3″·9.

P IV 269 (Σ **634**). v^h 1^m, N 79° 5′: 5·5, 9: 349°·1: 34″: light yellow, pale blue. Moving.

P XII 232, 230 (Σ **1694**). xii^h 48^m, N 84° 7′: 6, 6·5: 327°·3: 22″: bright white, 1833; so Σ 1832. [Some difference, 1852, 3$\frac{7}{10}$ in.: pale yellow? pale violet? not quite a match, 1863, 5½ in.]

1 (Σ **550**). iv^h 22^m, N 53° 38′: 7·5, 8·5: 307°·9: 10″·4: white, sapphire, 1838; so D. De green or blue, pale rose, 1854. Nearly half-way from α Pers. to δ Aur., a little *n* of line; in an ill-marked, but rich and beautiful district.

P VII 159, 160 (Σ **1122**). vii^h 34^m, N 65° 28′: 8, 8: 4°·7: 15″·6: white.

(7. (Σ **610**). iv^h 47^m, N 53° 33′: 4·2, 11·3: 238°·3: 26″: 4·2: white; test for large telescope (easy, 6 in. achr. Burnham, Chicago, 1871). De added, 1864, a companion, 7·9: 308°·8: 1″·2: olive. He had never seen so 'sombre' a star.)

(Σ **385**. iii^h 19^m, N 59° 29′: 4·7, 9: 161°·4: 2″·4: yellow.)

[11, 12 (Σ 13 App. I). iv^h 55^m, N 58° 43′: 5, 6: 7°·7: 181″: bluish, deep yellow or red; colours remarkable; yellowish white, pale red, 9 in. spec. 1872. Fine field.]

[CAMELOPARDUS]

[P III 97. III^h 32^m, N 59° 33′: 6, 9; Kn 34°·3: 55″·6: orange with scarlet glare (a hue sometimes found), blue.]

(Σ **396**. III^h 23^m, N 58° 19′: 6·3, 8: 241°·8: 20″·4: white.)

(Σ **1625**. XII^h 11^m, N 80° 51′: 6·5, 7: 218°·8: 14″·3: very white—sometimes placed in other constellations.)

(Σ **389**. III^h 20^m, N 58° 55′: 7, 8: 61°·8: 2″·8: white, purplish.)

(Σ **400**. III^h 24^m, N 59° 36′: 7, 8: 282°·6: 1″·5: yellowish, bluish white.)

[Σ **362**. III^h 6^m, N 59° 33′: 7·7, 8: 142°·3: 6″·9: very white. D quintuple. In a beautiful low-power group.]

(Σ **384**. III^h 18^m, N 59° 27′: 7·8, 9: 267°·5: 2″: golden, blue.)

(β. IV^h 53^m, N 60° 16′, 4·5 m. is a fine wide pair. Birm.]

[Red star. III^h 30^m, N 62° 15′: 8 m. Birmingham.]

Nebula.

801 (H IV 53). III^h 56^m, N 60° 29′. Plan.: small and dim. Closely *f*, 1½° *n*, is H VII 47, an elegant group with 7 m. pair, preceded by another, wider apart.

CANCER.

A constellation marked only to the naked eye by the remarkable cluster Præsepe.

Double Stars.

σ^2 (Σ **1291**). VIII^h 46^m, N 31° 4′: 5·5, 7: 335°: 1″·4: white, yellow. [Good test: elongated $3\frac{7}{10}$ in. 80; divided, 144.] ι^2 of Fl, H, H, South, Σ, who finds diff. of mag. var.

[CANCER]

ι (Σ 1268). VIII^h 39^m, N 29° 14′: 5·5, 8: 307°·8: 30″: pale orange, clear blue. Beautiful contrast.

ζ (Σ 1196). Triple. VIII^h 5^m, N 18° 2′: 6, 7, 7·5: 28°·3, 149°·4: 1″·3, 5″·4, 1832; 322°·7, 144°·1: 0″·9, 4″·8, 1853; De 134°·4: 5″·6, 1870; D 6, 7: 243°·4: 0″·6, 1865; [well separated, 8 in. 'With' silv. spec. power 300, 1865]; Kn 166°·9: est. 0″·6; Christie (Greenw. 12·75 in. achr.) 157°·6: 0″·4±; Key, 18 in. spec. est. 0″·55, 1872 (periastron): yellow, orange, yellowish, 1832-1843; De all white, 1854–5–6; 7·5 yellowish or olive, 1864–5. Binary; close pair revolving in not much less than 100 (Jacob, 110) y.; Plummer however gives 58·23;—companion in a period of ages. Excellent test; pointed at by α and β Gem: at twice their distance.

ϕ^2 (Σ 1223). VIII^h 19^m, N 27° 23′: 6, 6·5, 1833, 1843: 213°·9: 4″·8: white, pale white, 1849; De yellow, 1854; [much less unequal, 1849; nearly equal, 1856; still more striking if compared with v^1; $\frac{1}{4}$ or $\frac{1}{3}$ m. diff. 9 in. spec. 1872.] Σ gave 6, 6·5 of his scale, 1826; De 6·5, 6·5, 1854.

σ^4 (Σ 1298). VIII^h 53^m, N 32° 48′: 6, 9: 136°·4: 4″·8: lucid white, sky-blue. 66 of Proctor's Atlas.

Σ 1177. VII^h 58^m, N 27° 54′: 6·5, 7·4: 354°·5: 3″·5: [white, greyish].

v^1 (Σ 1224). VIII^h 19^m, N 25° 0′: 7, 7·5: 40°·1: 5″·8: creamy white, pale blue. Σ 1·1 m. diff. 1830; De almost as much, 1855 [considerably unequal, 1849].

[Σ 1311. IX^h 0^m, N 23° 30′: 6·7, 7·1: 200°·5: 7″·2: white. A little n p ξ, 5 m.]

[Σ 1228. VIII^h 20^m, N 27° 59′: 8, 8·5: 352°: 8″·9: very white. Not far from line joining ϕ^1 and ϕ^2, nearer the former.]

[CANCER]

(6. Triple. VI^h 54^m, N 28° 9′: 5, 13, 14: est. 70°, 180°: 70″, 65″. Birmingham.)

[Red star, H. VIII^h 48^m, N 17° 46′: 8·5 m. [8 m.? 1872.]

Clusters.

1681 (M 44). VIII^h 33^m, N 20° 24′. The Præsepe of the ancients, just resolved by the naked eye; too large for usual fields, but full of fine combinations: two triangles will be noted. Galileo counted 36 stars in it, with his newly-constructed telescope.

1712 (M 67). VIII^h 44^m, N 12° 17′. Cl. (H about 200 stars, 10—15 m.) Visible in finder.

CANES VENATICI.

The nebulæ here are fine. The only prominent star comes first on the list.

Double Stars.

12 (Σ **1692**. Cor Caroli). XII^h 50^m, N 39° 4′: 2·5, 6·5: 227°: 19″·8: flushed white, pale lilac, 1837; full white, very pale, 1850; pale reddish white, lilac, 1855; Σ white, 1830; H 'with all attention I could perceive no contrast of colours,' 1830–1; De white, pale olive blue, 1856; Kn very pale yellow, pale lilac, 1865; Grover creamy, fine blue, 1867; [white or yellowish, tawny or lilac, 1850, 3$\frac{7}{10}$in.; ditto, little contrast, 5½ in. achrom., 1862; pale yellow, fawn colour, 1865; pale yellow, pale copper, 9 in. spec. 1870.] Relatively fixed for 73 y., yet considerable c. p. m. Here again unequal stars must be at the same distance from us.

2 (Σ **1622**). XII^h 10^m, N 41° 26′: 6, 9: 259°·5: 11″·3:

[CANES VENATICI]

golden yellow, smalt blue [striking, though not conspicuous; $\frac{1}{3}$ from Cor Caroli towards δ Leon.]

(Σ **1606**). XII^h 4^m, N 40° 37′: 6·3, 7: 348°·6: 1″·4: white.)

Nebulæ.

3572 (M 51). XIII^h 24^m, N 47° 52′. E. of Rosse's wonderful spiral: its wreaths of stars are beyond all but the first telescopes; common ones will only shew two very unequal nebulæ nearly in contact, both brightening in the centre: traces of the halo encompassing the larger may perhaps be caught; Sm could not do more: 'the enigma is another unequivocal mark of the illimitable power of the SUPREME CREATOR!' [9$\frac{1}{3}$ in. spec. shewed plainly outer end of spiral, and junction with smaller neb.] Huggins spectrum not gaseous. A misty spot in finder, 3° *s p* Alkaid, at end of Great Bear's tail.

3636 (M 3). XIII^h 36^m, N 29° 1′. 'A brilliant and beautiful globular congregation of not less than 1,000 small stars' (Sm), *blazing* splendidly (that is, running up into a confused brilliancy) towards the centre, with many outliers. H 11—15 m., making lines and irregular rays. 3$\frac{7}{10}$ in. hardly resolved it. Buffham centrally resolved, 9 in. 'With' mirror; [sprinkled over and surrounded by the larger stars, 9$\frac{1}{3}$ in. spec.] In a triangle of stars, rather nearer Arcturus than Cor Caroli.

3258 (M 94). XII^h 45^m, N 41° 50′. Small bright neb. like a comet; resolvable, Sm: a little *p* Cor Caroli, 2$\frac{1}{2}$° *n*.

3474 (M 63). XIII^h 10^m, N 42° 43′. Oval, not bright. H saw it 9′ or 10′ long, and near 4′ broad, with a very brilliant nucleus. An 8 m. star lies *p*, a minute triplet *f*. E. of Rosse spiral? Huggins continuous spectrum.

CANIS MAJOR.

α (Sirius). $\text{VI}^h\ 39^m$, S 16° 32′. This is the leader of the host of heaven: a glorious object, in all likelihood either far greater or more splendid than our Sun. It has been perceived at midday with ½ in. aperture. Bond II. saw it with the naked eye in broad sunshine. Its colour has probably changed. Seneca called it redder than Mars; Ptolemy classed it with the ruddy Antares. I now see it of an intense white, with a sapphire tinge, and an occasional, probably atmospheric, flash of red. Hind and Pogson have found similar decided changes of colour in variable stars. In the spectrum of Sirius, and many white stars, the lines of hydrogen are abnormally strong, all those of the metals remarkably faint. The very minute parallax of Sirius indicates an inconceivable distance, far surpassing, probably, that of many telescopic stars. From irregularities in the proper motions of Sirius and Procyon, Bessel fully believed that each was a member of a binary system, their companions being dark and invisible. This remarkable idea has been, to some extent, justified by A. Clark's discovery in 1861 of a 10 m. star, nearly at the required distance and angle, a most interesting object, which would not be difficult but for atmospheric hindrance; Bond 85°·1: 10″·4, 1862; Se 71°·3: 10″·1, 1866. OΣ thinks its mass must be at least half that of Sirius, but its nature very different, or it would shine as a 1 m. star. D asks, Is it an enormously large globe endued with very small light-producing power? or perhaps shining by reflection from Sirius? Other companions have been suspected. Spectroscopic observations have led Huggins to the conclusion that

[CANIS MAJOR]

Sirius was in 1868 receding from us with a velocity of 18 to 22 miles per second.

Double Stars.

μ (Σ **997**). $\text{VI}^h\ 50^m$, S 13° 53′: 5·5, 9·5 : 342°·9 : 3″·5, 1834; De 337°·2 : 2″·8, 1864 : topaz yellow, grey. 3° *n f* α, among rich fields.

ν^1. $\text{VI}^h\ 31^m$, S 18° 33′: 6·5, 8 : 260°·2 : 17″: pale garnet, grey. Powell angular motion, 1856. 3° *s p* α.

30. $\text{VII}^h\ 13^m$, S 24° 43′: 6·5, 9: 73°: 85″: white, pale grey. In a rich cluster, H VII 17. [About 1° 50′ *n*, 1° *p*, lies a very fine pair, 6·5, 8: fiery red, greenish blue.]

(Lalande **12936**. $\text{VI}^h\ 36^m$, S 15° 53′: 7, 10; Burnham; Kn 169°·4: 4″·1. *n p* α. Brightest of neighbourhood.)

Clusters.

1454 (M 41). $\text{VI}^h\ 41^m$, S 20° 37′. Superb group, visible to naked eye, 4° beneath α. [Larger stars in curves, with ruddy star near centre, 5½ in.:—H says the latter frequently occurs in clusters. See also note on Sagittarius, *infra.*]

1512 (H VII 12). $\text{VII}^h\ 12^m$, S 15° 24′. Beautiful cl. H 10 m: melting into a very rich neighbourhood, as though the Galaxy were here approaching us. 64 includes a bright white star *p*. Sm observes that the stars are nearly all 10 m. 3° *f* γ.

CANIS MINOR.

α (Procyon). $\text{VII}^h\ 33^m$, N 5° 34′. This fine pale yellow star (which see under Sirius *) has a curious var. about 2½′ distant, very nearly *f*; 8 m. Sm 1833; 9 m. Fletcher 1850;

* Vögel at Bothkamp thinks, from spectroscopic observations, Procyon may be receding from us 63 miles per second, Sirius 46.

missed by Bond 1848, Fletcher 1853, Hind 1853–4–5, Sm & D 1858; and still invisible. There are other minute stars in a large field. One, $5\frac{1}{2}'$ *f* α, was found double by Bird, with 12 in. silvered mirror, 1864, 9·5, 9·8; seen by Buffham with 9 in. d°. (With), and detected independently with 6 in. achr. by Burnham. D gives 195°: 0″·6. Severe test. A minute companion *n p*, Bird; D just sees it steadily with $8\frac{1}{4}$ in. achr. and gives it 11·8 m. (of Σ): 285°: 47″.

Double Stars.

14. Triple. VII^h 52^m, N 2° 34′: 6, 8, 9: 64°·9, 153°·4: 75″, 115″: pale white, 1831, bluish, blue [6 deep yellow, 1851, and 8 very little brighter than 9].

P VII 170 (Σ **1126**). VII^h 33^m, N 5° 32′: 7, 8: 132°·9: 1″·4: white, ash-coloured. Discs in contact, 144: occasionally just split, 250: admirable test, lying most conveniently *f* a little *s* of α, and being the largest star in that direction. It is often called 31 Can. Min. Bode. Possibly binary. [About 1° *s f* is a fine orange 7 or 8 m. star.]

(S. Var. red star, VII^h 26^m, N 8° 36′.)

CAPRICORNUS.

Not a conspicuous constellation, but containing some good objects, among which its principal star takes a high rank.

Double Stars.

α^2, α^1 (Σ 51 App. I). XX^h 11^m, S 12° 57′: 3 (α^2), 4 (α^1): 291°·4: 373″: pale yellow, yellow; Σ cols. exactly alike, 1835. A noble pair, obvious to naked eye. α^2 has a 16 m. companion at 5″, just seen once by Sm, easy to P Sm with $7\frac{1}{4}$ in.

[CAPRICORNUS]

at Teneriffe, and Burnham with 6 in. at Chicago. Buffham sees it with 9 in. spec. Alvan Clark has doubled it.

β^2 (Σ 52 App. I). xx^h 14^m, S 15° 11′: 3·5, 7: 267°·2: 205″: orange-yellow, sky-blue.

ρ. xx^h 21^m, S 18° 14′: 5, 9: 176°·7: 3″·8: white, pale blue, 1830; a 7·5 m. yellow star *f* considerably *s*. [pale yellow, ruddy purple, 1850: 7·5, a fine addition, seems violet or lilac.] Se finds movement here. Birmingham 2 minute *comites* to 7·5.

σ. xx^h 12^m, S 19° 31′: 5·5, 10: 176°·8: 54″: yellow, violet, 1837. [orange, blue, 1850: companion underrated? yellow, ruddy, 9 in. spec. 1870; and 10 m.]

o^2. xx^h 22^m, S 19° 1′: 6, 7: 239°·9: 22″: bluish, 1832 [white, bluish, 1850].

(π. xx^h 20^m, S 18° 38′: 6·5, 10: est. 145°: 3″·2. Burnham.)

[About xx^h 36^m, S 16°, is a pretty pair, 8, 9: lilac, perhaps bluish green. 1¼° *f* P XX 240, a little *n*.]

(Red star. xx^h 10^m, S 21° 45′: 6 m. pure ruby; H, perhaps his finest, but very low in the English sky.)

Nebula.

4687 (M 30). xxi^h 33^m, S 23° 44′. Moderately bright: beautifully contrasted with an 8 m. star beside it: comet-like with 64; with higher powers resolvable. H 12 m.: 'fine object.'—'What an immensity of space is indicated! Can such an arrangement be intended, as a bungling spouter of the hour insists, for a mere appendage to the speck of a world on which we dwell, to soften the darkness of its petty midnight? This is impeaching the intelligence of Infinite Wisdom and Power, in adapting such grand means to so dispropor-

tionate an end. No imagination can fill up the picture of which the visual organs afford the dim outline; and he who confidently probes the Eternal Designs cannot be many removes from lunacy.' (Sm.) It lies closely *p*, a little *n*, from 41, a 5 m. star.

CASSIOPEA.

Here lie a multitude of very rich Galaxy fields. The leader α is slightly var. 2 m. to 2·5 m. in 79·1 d. Birt gives 50·98 d. Snow always found it sharper and smaller, and more readily obscured by fog, than β or γ, even when equally bright.*

Double Stars.

γ. $0^h\ 49^m$, N 60° 1′ : 3 m.: Se & Huggins find a double spectrum like that of T Cor. Inserted for its beautiful contrast with the minute surrounding stars. About ½° *s* Ingall has pointed out a pretty little pair; red, blue, 1865.

η (Σ **60**). $0^h\ 41^m$, N 57° 8′ : 4, 7·5 : 87°·8 : 9″·8, 1830; Kn 125°·6 : 6″·8, 1865; 137°·9 : 6″·1, 1872 : pale white,

* A difference in the *aspect* of different stars, independent of magnitude, and sometimes of colour, has been noticed by several observers. Sm, speaking of a dull 11 m. star seen best by averted vision, remarks that 'there are many of much smaller magnitudes which shine quite sharply, and emit a strong blue ray.' Key says, 'We constantly meet with stars which loom large with a faint light, and others again very vivid, but contracted apparently to a point.' Babinet remarks that some stars have a peculiar power of overcoming twilight. A gives ζ Aurig. as a striking instance, among others, of singularly intense light for its magnitude. He says that red and yellow stars appear brighter in proportion to the superiority of the eye and instrument. Schmidt finds that red stars gain in twilight, lose by night, as compared with white ones, and that the position of the eyes is of material consequence in such estimates.

[CASSIOPEA]

purple, 1843; H and South red, green; Σ yellow, purple, 1832; so Fletcher, 1851; D yellow, blue, 1841; Miller white, dusky orange, 1851; P Sm yellow, Indian red, 1856; [yellow, garnet, 1850.] Binary: period about 700 y. Powell 181 y. Great c. p. m.

P II 72 (Σ **262**). Triple. II^h 18^m, N 66° 49′: 4·5, 7, 9: 274°·2, 107°·1: 2″·1, 7″·5, 1834; De 265°·9: 1″·9, 1862: yellowish white, purplish, fine blue: ι of Σ, A, Se; Hevel 35. D. [Fine but not easy, $3\frac{7}{10}$ in. 1850.]

ψ (Σ **117**). I^h 17^m, N 67° 27′: 4·5, 9: 102°·1: 32″, 1836; De 105°·1: 29″·7, 1865: golden yellow, ashy. 9 again double [$5\frac{1}{2}$ in. shewed it well], 252°·6: 2″, 1836; Σ, 8·9, 9·5: 253°·3: 3″, 1831; De 255°·3: 2″·8, 1865. Ternary?

P XXIII. 101, 100. XXIII^h 24^m, N 57° 50′: 5, 7·5: 270°·5: 74″: light yellow, white, 1830; pale white, yellowish, 1852 [7·5 pale lilac, 1854]. D has doubled 7·5 again; 222°: 1″·5, 1840. Another star 14 m. lies 345°: 20″ from it. [A 10 m. pair *f*.]

σ (Σ **3049**). XXIII^h 52^m, N 55° 2′: 6, 8: 323°·7: 3″: flushed white, smalt blue. A glorious low-power field.

(Σ **3053**. XXIII^h 56^m, N 65° 23′: 6, 7·3: 70°: 15″: fine yellow, fine blue.)

(Σ **163**. I^h 42^m, N 64° 13′: 6·2, 8·2: 33°·6: 35″: golden ruddy, blue; colours exceedingly remarkable.)

[β, $2\frac{1}{2}$ mag. $0^h{\cdot}2^m$, N 58° 26′ is a pointer to two pretty pairs, a short distance *s p*. The *p* one is Σ **3057**. 7·2, 9·3: 299°·6: 3″·6: yellowish, ashy. The closer and more interesting is Σ **3062**. 6·8, 7·9: 36°·7: 1″·25, 1823; 132°·6: 0″·4, 1835; Kn 269°·9: 1″·4, 1865; 282°·7: 1″·4, 1872: yellow. Binary of short period: Mädler gives 146·83 y.]

[CASSIOPEA]

[Nearer β is a curious and pretty little 8 m. triangle, suggesting actual, not optical, vicinity.]

κ. 0^h 26^m, N 62° 13′: 4: bright yellow, 1837 [white, 1850; a little yellowish, 1855], is a guide to a grand vicinity [one group resembles the letter Y].

ϕ. 1^h 12^m, N 57° 33′: 5 m. is attended by a beautiful group, 256 (H VII 42).

55. 11^h 4^m, N 65° 55′: 6 m. is *s* of the spot* where the Great New Star flamed out, Nov. 1572, speedily rivalling Venus, so as to be seen at noon-day, then fading during 16 months to utter extinction: there is some idea that similar appearances took place here in 945 and 1264; if so, we may possibly soon witness a repetition of this incomprehensible phænomenon. D'Arrest finds a star, 10–11 m. near its place, 1865, where A could formerly see none. This should be watched. The colour of the great star changed from white through yellow and red to blue. Hind thinks several variable stars increase blue, are yellow after maximum, and flash red in decreasing.

(R. Var. XXIII^h 52^m, 50° 40′: 6 m. to below 14 m. in 434·81 d. Vivid red.)

(Red star. 0^h 3^m, N 63° 11′: 8·5 m. H.)

Clusters.

392 (H VI 31). 1^h 37^m, N 60° 35′. Visible in finder; field very good, 64; 80 shewed Sm's little pair, 9, 10·5: 70°: 8″; but not his ruby 8 m, 1833. 2½° from δ, on line from α.

341 (M 103). 1^h 25^m, N 60° 1′. Beautiful field. 1° *f* a little *n* of δ.

* A, however, places this in 0^h 18^m, N 63° 26′.

[CASSIOPEA]

120 (H VIII 78). $0^h\ 36^m$, N 61° 5′. Fine cl.: somewhat like the letter W; half way from γ to κ.

5031 (H VI 30). $xxiii^h\ 51^m$, N 56° 0′. Beautiful large faint cloud of minute stars: H 11—18 m.: 'a most superb cluster;' 'a mere condensed patch,' as Sm remarks, 'in a vast region of inexpressible splendour, spreading over many fields;' including the whole Galaxy through this and the adjacent constellations. [A beautiful group in a rich field lies about $\frac{3}{4}$° *f* δ.]

CEPHEUS.

Much more barren to the naked eye than to the telescope. Glorious sweeps and curious groups between α and Galaxy.

Double Stars.

β (Σ **2806**). $xxi^h\ 27^m$, N 70° 0′: 3, 8: 251°: 14″: white, blue, 1833, 1843; yellowish, flushed blue, 1851. De yellow, violet, 1852, 1854; [white, blue, 1850.]

δ. (Σ 58 App. I). $xxii^h\ 24^m$, N 57° 45′: 4·5, 7: 192°·2: 41″: deep yellow, cerulean blue. An especially fine pair, somewhat like β Cyg. C. p. m. and revolution suspected. 4·5 is very regularly var. up to 3·5: period $5^d\ 8^h\ 30^m$: A adds 18^m. Schmidt suspects variation in many stars of Cepheus.

κ (Σ **2675**). $xx^h\ 13^m$, N 77° 19′: 4·5, 8·5: 123°·8: 7″·5: pale yellow, blue. Se suspects motion.*

ξ (Σ **2863**). $xxii^h\ 0^m$, N 64° 0′: 5, 7: 288°·8: 5″·8, 1839; De 286°: 6″·3, 1864: bluish, 1839; flushed, pale lilac, 1851;

* A peculiarly strange coincidence is too remarkable to be omitted, attested by an unimpeachable witness, the late Mr. Baily. The RA of this star was erroneously calculated by the two separate and independent computers, who *agreed precisely in every figure*: and the error was even unobserved by the vigilant eye of Mr. Stratford. On recomputing the place of this star, with a view to discover the cause of its discordancy,

[CEPHEUS]

Σ pale yellow, blue, 1831; De white, violet, 1854; [white, tawny or ruddy, 1850]. About 1° *n*, and as much *p*, is **Σ 2843.** 7·2, 7·5: 133°·5: 2″·4: white [not examined].

π. XXIII^h 4^m, N 74° 41′: 5, 10: 330°: 1″·8, 1843; Kn 6°: 1″·2, 1865: deep yellow, purple [not seen].

P XXII 11, 12. XXII^h 4^m, N 58° 39′: 6, 6·5, 1839: [very nearly equal, 1850:] 316°·8: 21″: white. Σ doubles 6·5 (**2872**). Just *p* λ: a little *n* of ζ.

P XXI 248 (Σ **2816**). Triple. XXI^h 35^m, N 56° 54′: 6, 8·5, 8·5: 120°·3, 339°·5: 11″·7, 19″·7: pale yellow, two grey.

P II 191 (Σ **320**). II^h 49^m, N 78° 59′: 6, 10·5: 225°·8: 5″·2: orange, smalt blue. Test for moderate instruments.

o (Σ **3001**). XXIII^h 13^m, N 67° 24′: 7, 9: 173°·8: 2″·5: orange yellow, deep blue.

[P XXI 51 (Σ **2780**). XXI^h 8^m, N 59° 29′: 6·2, 7·2: 226°·4: 1″·08: white. [A pale ruby star 7·5 m. *n f.*]

[Σ **2790**. XXI^h 16^m, N 58° 4′: 5·6, 9·9: 46°·6: 4″·5: very red [orange, 9 in. spec. 1871], blue.]

(Σ **2950**. XXII^h 46^m, N 61° 0′: 5·7, 7: 319°·1: 2″: yellow, ashy.)

(Σ **2751**. XX^h 59^m, N 56° 9′: 6, 7: 344°: 1″·9: very white.)

[Σ **2840**. XXI^h 48^m, N 55° 11′: 6, 7: 194°·1: 20″: greenish, bluish. [A splendid pair.]

(Σ **2873**. XXII^h 3^m, N 82° 15′: 6·2, 7: 77°·3: 13″·8: white.)

I myself fell into exactly the same error, and obtained *precisely the same figures*; and it was only on going over the operation a second time that I *accidentally* discovered that we had all inadvertently committed the *same* mistake!'—Memoirs of R. Astron. Soc. IV. 290.

[CEPHEUS]

(Σ **2883**. XXII^h 8^m, N 69° 29′: 6·2, 8·2: 254°·7: 14″·9: bluish, blue.)

μ. XXI^h 40^m, N 58° 11′. The celebrated 'Garnet sidus' of ♅, visible to naked eye, but var. 4 m. to 6 m. in 5 or 6 y., and hence probably omitted by Fl. ♅ says 'it is of a very fine deep garnet colour,' especially after viewing a white star, such as α. 2½° *s* of ν. [Deep orange, not crimson; 5½ in. 1864; so Slack, 1865; and 9⅓ in. spec. 1867.]

Cluster.

4957 (M 52). XXIII^h 18^m, N 60° 53′. Irregular, with orange star.

CETUS.

The largest, but far from the most interesting constellation. Its alphabetical leader α is now inferior to β: one or both may have changed. Huggins finds spectrum nearly as α Orion. α is worth looking at, as a fine combination of a beautiful 2·5 m. orange star with a 5·5 m., fine blue. Between them *f* is a pair 11 m.

o. II^h 13^m, S 3° 34′: yellow (H very full ruby): Mira, the celebrated variable, from 2 m. to invisibility, in 331^d 8^h 4^m 16^s according to A. Its maximum brightness and period are not always the same: A has shewn the probability of regular alternations in the latter to the extent of 25^d. One of the most interesting problems of modern astronomy is the question whether the irregularities of variable stars may not be, like the *maxima* and *minima* of sun-spots, phases of some general law.

Double Stars.

γ (Σ **299**). II^h 37^m, N 2° 41′: 3, 7: 285°·7: 2″·6: pale

[CETUS]

yellow, lucid blue, 1831–1843: De 7 olive-green, 1854 [tawny, 1850]. D angles very discordant. Σ c. p. m.

ν (Σ **281**). 11^h 29^m, N 5° 4′: 4·5, 15: 85°: 6″: pale yellow, blue. Sm 15 a glimpse-star; [easy, 5½ in., 1861.]

37 (Σ 3 App. I). 1^h 8^m, S 8° 37′: 6, 7·5: 332°·3: 51″: creamy white, dusky. Σ c. p. m. *n p* lies another pair, 8, 10: 20″: yellow, violet. 2° *p θ*.

42 (Σ **113**). 1^h 13^m, S 1° 11′: 6, 8: 332°·8, 1834; De 343°, 1863: 1″·2: bright white, white. [Moving. D questions this. I have not seen it.]

P O 146. 0^h 34^m, S 5° 4′: 6·5, 9: 289°·9: 58″: yellow, flushed blue.

66 (Σ **231**). 11^h 6^m, S 3° 0′: 7, 8·5: 229°·6: 15″·4: pale yellow, sapphire blue. C. p. m.? Σ angular movement. 1½° *p* Mira, a little *n*.

P O 113 (Σ **39**). 0^h 28^m, S 5° 16′: 7, 9: 44°·6: 19″·6: yellowish, fine blue. [9 over-rated? 1850.]

61. 1^h 57^m, S 0° 58′: 7, 11: 188°·8: 39″: pearly white, 1834 [pale orange, 1850], greenish. I found attendant very obvious with averted eye. Birmingham another *comes*, est. 13: 330: 55″. Followed a little *s* by Σ **218**. 7, 8·5: 249°·8: 4″·6: white, blue. [A little *p* this is a pale ruby, with distant *comes* 11 m. and *s p* a star 7 m. with 2 small attendants.] 61 is 3° *s* a little *f α* Piscium.

(58. 1^h 51^m, S 2° 42′: 6·5, 14: est. 15°: 3″·5; test for 6 in. Burnham. About 2° *s p* 61. P could not find 58.)

(Σ **150**. 1^h 37^m, S 7° 46′: 7·2, 7·8: 195°·5: 36″: very white.)

[*χ*. 1^h 44^m, S 11° 17′ forms a fine pair with P I 182. 5; 7·5: pale yellow, bluish. Closely *s p ζ*.]

[CETUS]

[About I^h 35^m, S 8° 0′ is a beautiful 8 m. pair, *s* a little *p* P I 167, 6 m.]

Nebula.

600 (M 77). II^h 36^m, S 0° 33′. 1° *f* δ, a little *s*. Small, faintish; very near a 9 m. star. H thought it at least 910 times more distant than 1 m. stars! But qu. these inferences now? E. of Rosse spiral, blue.

CLYPEUS (or SCUTUM) SOBIESKII.

This asterism, which worthily associates the memory of the Polish hero with the most brilliant part of the Galaxy visible in our latitudes, is full of splendid telescopic fields: and the very ground of the Milky Way seems here resolvable.

[Red Star. $XVIII^h$ 43^m, S 8° 3′: 9 m. H.]

Clusters and Nebula.

4397 (M 24). $XVIII^h$ 11^m, S 18° 27′. Magnificent region, visible to the unaided eye as a kind of protuberance of the Galaxy; and so considered by H, who gives stars 15 m. It is accompanied by two little pairs. 2° *n* of μ Sagittarii.

4400 (M 16). $XVIII^h$ 11^m, S 13° 50′. Grand cluster.

4401 (M 18). $XVIII^h$ 12^m, S 17° 11′. Glorious field in a very rich vicinity. *s* lies a region of surpassing splendour.

4432 (M 26). $XVIII^h$ 38^m, S 9° 32′. Coarse cluster.

4403 (M 17). $XVIII^h$ 13^m, S 16° 15′. The 'horse-shoe' neb. visible in finder, 1° *n* of M 18, described by Sm as 'a magnificent, arched, and irresolvable nebulosity,—in a splendid group of stars.' Well has he observed, 'the wonderful quantity of suns profusely scattered about here would be confounding, but for their increasing our reverence of the Omnipotent

[CLYPEUS (OR SCUTUM) SOBIESKII]

Creator, by revealing to us the immensity of the creation.' The neb., however, Huggins finds to be gaseous.

COMA BERENICES.

A gathering of small stars, which obviously at a sufficient distance would become a nebula to the naked eye.

Double Stars.

12. XII^h 16^m, N 26° 34′: 5, 8 : 168°·2 : 66″: straw-yellow, rose-red; Kn 8 grey lilac, 1872; [pale blue, 9 in. spec. 1872.] 1½° *sp* 16, the 'lucida' of the constellation. [The latter beautifully placed in a little triangle of 8 or 9 m. stars; a curious row of 4 stars *p*.]

35 (Σ **1687**). Triple. XII^h 47^m, N 21° 57′: 5, (not given; Kn 7·5, 1872), 10: 42°, 126°·5 : 1″·5, 29″, 1843; Kn 52°·9 : 1″·3, 1865; De 55°·6: 1″·2, 1869: pale yellow, lilac, full blue. Binary. [Not well examined.]

24 (Σ **1657**). XII^h 29^m, N 19° 6′: 5·5, 7 : 272°·1 : 21″: orange, lilac [striking and beautiful contrast, 1872].

2 (Σ **1596**). XI^h 58^m, N 22° 11′: 6, 7·5 : 239°·9: 3″·6 : pearly white, lilac.

P XII 202, 201 (Σ **1685**). XII^h 45^m, N 19° 53′: 7·5, 8 : 201°·9 : 16″·2 : white. 2° *s* of 35.

[Σ **1633**. XII^h 14^m, N 27° 47′: 7·1, 7·2 : 245°·1 : 8″·7 : very white.—Bode 55. [A solitary object.]

[17. XII^h 22^m, N 26° 38′, forms a fine pair (Σ 21 App. I) with P XII 96; colours somewhat different. Σ white, bluish white. The smaller star, by averted vision, seemed more surrounded than the other with scattered light, 3$\frac{7}{10}$ in. 1852; not perceptible, 9 in. spec. 1872.]

[COMA BERENICES]

Nebulæ.

1558 (M 53). XIII^h 7^m, N 18° 52′. Brilliant mass of minute stars (H 11—15 m.), blazing in centre. H curved appendages. [Not very bright, $3\frac{7}{10}$ in.—beautiful, 9 in. spec.]

3321 (M 64). XII^h 50^m, N 22° 23′. Magnificent large bright neb. blazing to a nucleus. H resolvable, nucleus probably double star, with vacuity below it. [rather faint, $3\frac{7}{10}$ in.]

3106 (H V 24). XII^h 30^m, N 26° 42′. Long streaky neb. with parallel patch on *f* limb; 'extraordinary phænomenon.' [very faint, $3\frac{7}{10}$ in.; well seen, 9 in. spec.]

[2946 (M 85). XII^h 19^m, N 18° 55′. Fair specimen of the many nebulæ in this region: midway from 24 towards 11, the nearest conspicuous star *p*, a little *s*.]

CORONA BOREALIS.

A constellation resembling more than usual the object whose name it bears.

Double Stars.

ζ (Σ 1965). XV^h 34^m, N 37° 4′: 5, 6: 301°·2: 6″·1: flushed white, bluish green.

ν^2 (Σ 29 App. I). XVI^h 18^m, N 34° 0′: 5, 12 [10, 1850, 1855]: 17°·9: 137″: pale yellow, 1838 [deep yellow, 1855], garnet, forms a fine group with ν^1, 5 m. deep yellow, and a 6 m. grey star *f*. $5\frac{1}{2}$ in. shew a minute comes to ν^1.

η (Σ 1937). XV^h 18^m, N 30° 46′: 6, 6·5: 57°·2: 0″·8, 1832; 188°·5: elong. 1846; D 27°·5: 1″·1, 1865; Kn 35°·7: 1″, 1867; 45°·8: 1″, 1871: white, golden yellow. One of H's severest tests. It would have been interesting to look at

[CORONA BOREALIS]

so wonderful an object as a pair of suns revolving in the brief period of 43 y. (Winnecke), even though we could only see them closed up into one; but it has been much easier of late. Visible to naked eye, a little out of the curve of the coronet. Sm speaks of a glimpse-star *nf.* I have seen it with $9\frac{1}{3}$ in. mirror; Buffham 6·2 in.

σ (Σ **2032.**) xvi^h 10^m, N 34° 11′: 6, 6·5: 107°·6: 1″·3, 1830; Se 192°·4: 3″, 1865; Kn 194°·7: 3″, 1867; 195°·3: 3″·2, 1871: creamy white, smalt blue, 1830—1843; but colours questionable; P Sm 6 bluish, 1856; South 6·5 'certainly not blue; it differs very little from the large star in colour,' 1825; Σ 6·5 white, 1836; De 6, 6·5 yellow, yellow sometimes ashy, 1854–5; white, ashy, 1856; red, doubtful blue, 1857; Se 6·5 sometimes blue, sometimes yellow, 1855—1857; Kn very pale yellow, blue, 1871; [6·5 sometimes ruddy, sometimes bluish, 1850, 1855, $3\frac{7}{10}$ in. more than $\frac{1}{2}$ m. difference, 1855; bluish, more than $\frac{1}{2}$ m. $5\frac{1}{2}$ in., 1862; De rated them 5·3, 6·5, 1854–5; Se mags. very discordant.] Binary; period very uncertain; extremes, Hind, 737 y. Jacob, 195 y. Followed at 44″, 1839, by a little blue star, 11 m. Sm. 15 or 20 m. South, 1825, not visible with more than 92 of a very fine 5 in. achrom. [readily seen with 80, 144, 250 of $3\frac{7}{10}$ in. 1850.] De distance more than 51″, 1862, from c. p. m. of pair. 2° *p ν*.

[Σ **1932.** xv^h 13^m, N 27° 19′: 5·6, 6·1: 273°·8: 1″·6, 1830; De 290°·3: 1″·2, 1863: very white: mags. var.? Binary. $2\frac{1}{2}$° *p a*, 10′ *n.*]

(*θ.* xv^h 28^m, N 31° 46′, 4·5 m. is followed, a little *s*, by two pairs, 7·5, 9; and 9,9: 5″. Birmingham.)

(T. xv^h 54^m, N 26° 18′. The 'Blaze star' with a double

spectrum, from the addition of the bright lines of hydrogen gas; discovered by Birmingham, 2 m., 1866, May 12; 8·5 m. May 24; afterwards to 9 m.; reviving to 7 and 7·5 m., Aug. 20; Oct. 5. This marvellous object should be carefully watched, especially as it had previously shown signs of unsteadiness. Backhouse finds it still irregularly decreasing, 1872. H gave it 6·3 m., 1842. A, 9·5 m., 1855. $\frac{1}{3}$ from ϵ Cor. towards π Serp. Baxendell found it at one time buff, with a tinge of blue over it. See o^2 Cyg.)

CORVUS.

This small constellation contains several conspicuous stars.

Double Stars.

β. XII^h 28^m, S 22° 41′: ruddy yellow, 1831 [pale yellow, 1852]. The companions in the Bedford Catalogue are distant: but it is inserted to be watched for variation. Sm found, 1831, that though possessing no Arabic name, and lettered β by Bayer, it was unquestionably the brightest in the constellation. H, 1783, gave the order of brightness $\gamma\ \delta\ \beta\ \alpha$; 1796, $\gamma\ \beta\ \delta\ \alpha$, with but little difference between them: I found the order, 1852, 1854, 1859, 1861, $\gamma\ \delta\ \beta\ \alpha$.

δ. XII^h 23^m, S 15° 47′: 3, 8·5: 210°·9: 24″: light yellow, purple.

CRATER.

Like Corvus, an appendage to Hydra.

Double Stars.

17. XI^h 26^m, S 28° 33′: 5·5, 7, 1833: 207°·8: 10″·1, 1833; Wrottesley, 211°·4: 8″·8, 1857: lucid white, violet.

[CRATER]

C. p. m. 7 var.? [Only ½ m. difference, 1852. So Wrott. 1857.]

P XI 39 (Σ 1530). xi^h 13^m, S 6° 11′: 8·5, 9: 315°: 8″: bluish white. [A 10 m. pair in field. About 45′ *p* is a fine pair, 7, 9: white, bluish or lilac.]

(β, see in Appendix, No. II.)

Red star. An 8 m. star, according to H, 'scarlet, almost blood-colour; a most intense and curious colour,' follows α (x^h 53^m, S 17° 24′) 42^s·5, 1′ *s*. Baxendell finds it var., and calls it R Crat. A 9 m. star, pale blue, *p*.

CYGNUS.

This fine cruciform constellation occupies a prominent position in the Galaxy, and nothing can be more magnificent than its low-power fields. Its principal star, Deneb, has no perceptible parallax, or proper motion; so far deserving the title, usually very inappropriate, of a 'fixed star;' hence we must infer amazing distance, and magnitude surpassing possibly that of Arcturus, Wega, or even Sirius itself. Huggins believes that it is approaching us at about 39 miles per second.

Double Stars.

β (Σ 43 App. I). xix^h 25^m, N 27° 41′: 3, 7 (var.?): 55°·6: 34″: golden yellow, smalt blue. One of the finest in the heavens. I have seen the colours beautifully by putting the stars out of focus. Sm observes that they are actually different, not, as may sometimes be the case, complementary, from mere contrast; an effect which is seen when the bright yellow light of a lamp makes the Moon appear blue, and which Schmidt witnessed to a remarkable degree at his observatory on Vesuvius

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during the great eruption of 1855, when the sky was as green as bottle-glass, and the Full Moon a lively green, through openings in red clouds of smoke and steam. A similar result may take place with some double stars, but not with all, as is proved by hiding the larger star behind a bar in the field. On this account the presence of artificial light is objectionable in observations of the colours of stars.

δ (Σ **2579**). XIX^h 41^m, N 44° 49′: 3·5, 9: 30°·9: 1″·5, 1837; Kn 348°·3: 1″·7, 1866; 337°·9: 1″·7, 1871: pale yellow, sea-green (Kn fine blue). Difficult with moderate apertures, because 9 falls on interference-ring: has been thought var. Seen by Buffham with 6½ of 9 in. 'With' spec. Hind gives period about 180 y.—12′ *n* Dawes found a pair 7·5, 11·25: 266°: 2″·3.

o^2 (Σ 50 App. I). Triple. XX^h 10^m, N 46° 21′: 4, 7·5 (P XX 63), 5·5 (o^1): 174°·1, 333°·8: 107″, 338″: orange, two blue, 1838. Sm found both the smaller stars cerulean blue when the larger one was concealed; Σ also called them blue, 'insignes,' 1836. But I have noted 5·5 white, 3$\frac{7}{10}$ in., 1850; white or yellowish, 'with an eye of blue,' 5·5 in., 1865; 'pale yellow with a cast of blue, a strange but accurate description,' 9⅓ in. silver, 1867, 1869. (See T Cor.) There is a 16 m. 330°: 15″; a light-test [not seen].

μ. Triple. XXI^h 38^m, N 28° 10′: 5, 6, 7·5: 114°·3, 61°·2: 5″·4, 217″: white, two blue: these colours should be watched; observers differ. Σ finds c. p. m. in the close pair (**2822**).

χ (Fl. P. Sm.) (Σ **2580**). XIX^h 41^m, N 33° 26′: 5, 9: 72°·9: 26″: golden yellow, pale blue. Relatively fixed, c. p. m. Beautiful field. About 4^m *f*, 50′ *s* is 17, or χ Bayer, discovered by Kirch, 1686, to be var., sometimes up to 5 m., period about 406d., splendidly red; many of the same class

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have this hue. It is *not*, as Sm states after Piazzi, P XIX 295, which lies between the other two stars. Stone proposes to call the pair χ^1, the var. χ^2. (See Appendix I.)

ω^3. xx^h 27^m, N 48° 47′: 5, 10: 318°·9: 55″: pale red, grey. P XX 199: 7, 9·5: 61″: white, pale blue, precedes it, making a fine group. Two feeble stars, which direct vision with my $3\frac{7}{10}$ in. would just reach, form a trapezium with ω^3.

61 (Σ **2758**). xxi^h 1^m, N 38° 5′: 5·5, 6: 96°·3: 16″·3, 1839; Kn 111°·7: 18″·8, 1866; 113°·4: 19″·2, 1871: yellow, deeper yellow. One of the most interesting objects in the sky. These suns were the first of the host of heaven to reveal to Bessel the secret of their distance.* This is probably 657,700 times that of the Earth from the Sun—itself 91,328,600 miles—a space so vast, that light, which reaches us from the Sun in 8^m, employs more than 10 years to traverse it: we see these stars, therefore, not as they are now—for of their present existence we have no information—but as they were 10 years ago.†

* The binary character ascribed to them has been doubted, and the change referred to a very large proper motion, but it probably exists. Bessel's grand result was obtained with the Königsberg Heliometer. The instrument absurdly so termed, as if it were intended to measure the *Sun*, has an object-glass cut into two halves; a slight displacement of these by producing a double image affords the means of accurate measurement. There is a fine heliometer at Oxford, $7\frac{1}{8}$ in. aperture.

† From the successive transmission of light results the extraordinary fact that the aspect of the whole heavens is of unequal date, each star having its own time of 'light-passage' to our eyes, and those times immensely differing, so that there is no impossibility in Humboldt's magnificent assertion, 'much has long ceased to exist before the knowledge of its presence reaches us; much has been otherwise arranged.' As Huggins remarks, the outburst of T Coronæ may have occurred many years ago.

[CYGNUS]

How vast must be the dimensions of this great Universe! What a temple for the Creator's glory! 'All the whole heavens are the LORD'S'—those heavens are crowded with millions upon millions of stars; and of all that countless multitude, millions, probably, for one, are at a distance incalculably exceeding that of 61 Cygni!

ψ (Σ **2605**). xix^h 52^m, N 52° 6′: 5·5, 8: 184°·2: 3″·5: bright white, lilac.

52 (Σ **2726**). xx^h 40^m, N 30° 15′: 5·5, 9·5: 56°·9: 7″: orange, blue. 3° *s* of ε. 4^m 55^s *f*, 10′ *n* of 52 is Lalande 40318. 7, 11·5: est. 290°: 1¼″. Burnham.

P XX 429 (Σ **2741**). xx^h 54^m, N 49° 57′: 6, 7·5: 34°·6: 2″·1: silvery white, pale grey.

P XIX 278. xix^h 41^m, N 34° 42′: 6, 8: 28°·8: 39″: straw colour, smalt blue. [Very beautiful.] 1¼° *n* of χ.

49 (Σ **2716**). xx^h 36^m, N 31° 51′: 6, 9: 48°·8: 3″·2: golden yellow, blue. 2° *s p* ε.

16 (Σ 46 App. I). xix^h 38^m, N 50° 13′: 6·5, 7, 1834 [not much inequality, 1850–1; nearly equal, 9 in. spec. 1871; Σ 5·1, 5·3, 1829–35]: 136°·4: 37″: pale fawn colour. Σ c. p. m. Within 1° *n f* θ.

P XXI 1 (Σ **2762**). xxi^h 3^m, N 29° 41′: 6·5, 9: 316°·5: 3″·5: dull white, pale lilac. 1½° *p* ζ.

P XX 452 (Σ **2748**). xx^h 57′, N 39° 0′: 7, 11: 297°: 17″: deep yellow, emerald [11 obvious, 1850, several hours past meridian].

P XIX 276 (Σ **2578**). xix^h 41^m, N 35° 47′: 8, 8·5: 126°·5: 15″: white.

P XIX 149 (Σ **2534**). xix^h 23^m, N 36° 16′: 8·5, 9: 61°·9: 7″: white, pale blue. Fine field: closely *f* 4, a 5 m. star.

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[Σ **2486**. XIX^h 9^m, N 49° 36′: 6, 6·5; [equal, 9 in. spec. 1871:] 224°·8: 10″·5: yellow. [Singular and beautiful field.]

(Σ **2671** XX^h 15^m, N 54° 59′: 6, 7·4: 341°·1: 3″: white, ashy.)

(Σ **2705**. XX^h 33^m, N 32° 55′: 6·5, 8: 262°: 3″: yellow, blue.)

(Σ **2666**. XX^h 14^m, N 40° 20′: 6·5, 8·7: 242°: 2″·7: very white, bluish.)

[Σ **2607**. XIX^h 54^m, N 41° 55′: 7·2, 9: 293°·4: 3″·2: white, ashy; [orange, blue, 9 in. spec. 1871.]

[Σ **2708**. XX^h 34^m, N 38° 11′: 7, 8·7: 355°: 10″·5, 1828: yellow, blue. Moving.]

(Pair. XIX^h 27^m, N 28° 0′: 7·5, 10: est. 355°: 5″: blue, red. Birmingham.)

(Pair. XIX^h 25^m, N 28° 27′: 7·5, 12: est. 90°: 40″: red, intense blue. Birmingham.)

[An open pair, 8, 8·5: white, in a fine field, lies about 30′ *s* from *α*, a little *f*.]

(R. In field with *θ*, XIX^h 33^m, N 49° 55′; Pogson's var.: 7 to 14 m. in 425 d.)

[U. XX^h 15^m, N 47° 30′: 8: red, Birmingham. Kn var.]

[Red stars. XXI^h 38^m, N 37° 25′: 8m. Bessel.—XXI^h 39^m, N 37° 13′: 8·5 m.: intense ruby, H.—XIX^h 53^m, N 43° 55′: 9 m. (A 8·2) Webb.—XX^h 9^m, N 38° 20′: 9 m. (A 8·2) Webb.]

Clusters.

4681 (M 39). XXI^h 28^m, N 47° 52′. Brilliant group and vicinity.

[4575 (H VIII 56). XX^h 18^m, N 40° 18′. Beautiful group, H 10—12 m. ½° *n* of *γ*, a little *f*.]

[DRACO]

Double Stars.

μ (Σ **2130**). XVII^{h} 3^{m}, N 54° 39′: 4, 4·5: 206°·7: 3″·6, 1830; 200°·3: 3″·3, 1839; Se 181°·8: 2″·8, 1865: white, pale white. Binary; period 600 years?

ν^{1} (Σ 35 App. I). XVII^{h} 30^{m}, N 55° 16′: 5, 5: 311°·8: 62″: pale grey. C. p. m.

39 (Σ **2323**, 36 App. I). Triple. XVIII^{h} 22^{m}, N 58° 43′: 5, 8·5, 7: 5°·5, 21°·7: 3″·3, 89″: pale white, light blue, ruddy.

o (Σ **2420**). XVIII^{h} 49^{m}, N 59° 14′: 5, 9: 347°·6, 1830; 345°·5, 1837: 30″: orange, lilac.

ψ^{1} (Σ **2241**). XVII^{h} 44^{m}, N 72° 13′: 5·5, 6: 14°·9: 31″: pearly white, 1838; Σ white, 1832 (with c. p. m.); De whitish yellow. ashy yellow, 1856; [yellow, lilac, contrast evident, 1850.]

40, 41 (Σ **2308**). XVIII^{h} 10^{m}, N 79° 59′: 5·5, 6: 235°·3: 19″·9: white, 1839; [yellow, paler yellow, 3$\frac{7}{10}$ in. 1856; so 5$\frac{1}{2}$ in. 1863; grouped finely with a smaller lilac star.]

ϵ (Σ **2603**). XIX^{h} 49^{m}, N 69° 56′: 5·5, 9·5: 354°·6: 3″·1: light yellow, blue: 9·5 var.? H and South very difficult; easy to me, and apparently under-rated. Contrast very pleasing.

17 (Σ **2078**, 30 App. I). Triple. XVI^{h} 33^{m}, N 53° 11′: 6, 6·5, 6 (16 Drac.): 115°·7, 194°·6: 3″·8, 90″: pale yellow, faint lilac, white. Σ, 1833, close pair white, altern. var.

P XVII 147 (Σ **2180**). XVII^{h} 26^{m}, N 50° 58′: 8, 8·5: 266°·2: 3″·2: pale white, ruddy, 1836; De white, 1854. 1$\frac{1}{2}$° *s* of β, the Dragon's eye.

[η. XVI^{h} 22^{m}, N 61° 48′: 2·5, 10: 141°·4: 4″·7: pale yellow, blue. D.]

(Σ **2348**. XVIII^{h} 31^{m}, N 52° 15′: 5·9, 8·1: 272°·7: 26″: yellow, blue, very fine colours.)

[DRACO]

(Σ **2403**). xviii^h 43^m, N 60° 55′: 6·2, 9: 258°·7: 1″·8: yellow, blue.)

(20 (Σ **2118**). xvi^h 55^m, N 65° 20′: 6·4, 6·9: 246°·4: 0″·8: white, one or both var. Discovered by H. Test.)

(Σ **2218**. xvii^h 39^m, N 63° 44′: 6·5, 7·7: 356°·7: 2″·5: white, ashy.)

(Σ **1516**. xi^h 7^m, N 74° 11′: 7, 7·5: 298°·7: 9″·9, 1831; Se 29°·6: 2″·6, 1856; De 70°: 4″, 1863: yellow, ashy yellow.)

[46. xviii^h 40^m, N 55° 24′: 5, 9: full yellow, clear blue; fine contrast.]

[About xiii^h 23^m, N 65° 23′, is a striking pair, 6·7, 6·7 (A): yellowish, with a smaller *comes*, blue.]

Nebula.

4373 (H IV 37). xvii^h 59^m, N 66° 38′. Plan. very curious. I found it much like a considerable star out of focus; very bright for its class. H gave it 35″ diam. I saw but 15″ or 20″ with $3\frac{7}{10}$ in. and could not well make out Sm's pale blue colour. H perceived a very small nucleus, which to Bird appeared, 1863, with a 12 in. silvered mirror as a 10 m. star. Huggins finds gaseous spectrum: the first of these surprising discoveries, 1864, Aug. 29. Nearly half way between Polaris and γ Drac. in pole of Ecliptic. About 40′ *n p* Bird finds a delicate triple star, 8·9, 9, 11·8.

EQUULEUS.

This little asterism is easily recognised by the clustering of its stars, and its bearing from Pegasus. There are some good objects, and many interesting low-power fields.

[EQUULEUS]

Double Stars.

ε (Σ **2737**). xx^h 53^m, N 3° 48′: 5·5, 7·5: 78°·1: 11″·2: pale yellow, bluish lilac. The larger is an interesting and beautiful binary star. Σ 5·7, 6·2: 294°: 0″·35, 1835; Sm 290°: 0″·5, 1838; Se 290°·2: 1″·1, 1866. [Just separated, 5½ in. 170, 1865. A 13m. star *n f*, 9 in. spec. 1871.] Se and Kn suspect motion in 7·5.

β. Quadruple. xxi^h 16^m, N 6° 15′: 5·5, 13, 14: 317°, 275°: 35″, 50″: lucid white, grey, blue. 13 has a most minute dusky 16 m. *comes*, 15°: 3″. [Of this most severe test, 3$\frac{7}{10}$ in. shewed 13? only; 9 in. spec. 13 and 14, now the larger, 1871.]

λ (Σ **2742**). xx^h 56^m, N 6° 40′: 6, 6·5: 225°·6: 2″·6: white. A beautiful close pair.

P XX 376 (Σ **2735**). xx^h 49^m, N 4° 2′: 6, 8: 286°·8: 1″·8; Σ, Se, Kn 2″·1: orange, purple, 1833; De white, blue, 1854. [Elong. 80; clearly divided, 144.] Second star *p* ε, *n*.

P XX 355, 356. xx^h 46^m, N 6° 51′: 8·5, 8·5: 145°: 40″: white.

[δ, xxi^h 8^m, N 9° 29′, 4·5m. is an excessively close pair, period 7 y? discovered by OΣ, with a distant *comes* 11 m.: 36°·8: 28″, 1838; Kn 27°·5: 34″, 1865: from great prop. mot. of δ. It is followed by 3 little stars, singularly arranged in a straight line.

γ, xxi^h· 4^m, N 9° 37′, and 6 (Σ 54 App. I), 5, 6: pale yellow, white or bluish; are a striking pair. Kn finds γ double, 4·75, 11: 276°·8: 2″·1: pale yellow, blue.

[Between α, xxi^h 9^m, N 4° 43′, and δ is a wide 7 m. pair, white.]

[About xxi^h 28^m, N 6° 5′, two pairs form a pretty field.]

ERIDANUS.

An asterism winding down to S. horizon, its *lucida* being out of sight in our latitudes.

Double Stars.

32 (Σ **470**). III^h 48^m, S 3° 20′: 5, 7 : 346°·5 : 6″·6: topaz yellow, sea-green or flushed blue. Se colours *magnifici, superbi.*

o^2 (40). IV^h 10^m, S 7° 50′: 5, 9·5 : 107°·6 : 82″: orange, sky-blue. Relatively fixed, with very large c. p. m. [9·5 is double, Kn est. 125° : 2″, 1871. Binary ?]

39 (Σ **516**). IV^h 8^m, S 10° 35′: 5, 11 [perfectly easy]: 154°: 7″·1 : full yellow, deep blue.

62. IV^h 50^m, S 5° 23′: 6, 8: 73°·6: 64″: pale white, flushed blue, 2½° *p* β (to which Birm. sees a minute *comes*).

P III 98 (Σ **422**). III^h 30^m, N 0° 10′: 6·5, 9: 231°·8: 5″·9, 1834; 235°·9: 6″, 1845: yellow, pale blue.

55 (Σ **590**). IV^h 37^m, S 9° 2′: 7·5, 7·5 : 318°·5 : 10″·2 : yellowish white.

(ρ^2. II^h 56^m, S 8° 12′: 5·5, 10 : est. 85° : 3″. Burnham. [Red Star, about 35′ *s f* β; 9·5m. Webb.]

Nebula.

826 (H IV 26). IV^h 8^m, S 13° 4′. Plan. bright and round with low powers of $3\frac{7}{10}$ in. but not bearing magnifying. Lassell describes it as the most interesting and extraordinary object of the kind he had ever seen; an 11 m. star standing in the centre of a circular nebula, itself placed centrally upon a larger and fainter circle of hazy light. Yet Huggins finds the spectrum, though deficient at the red end, not gaseous.

GEMINI.

The leading stars, in the heads of the two figures, are well known, but it requires a little attention to the globe or map to make out the whole constellation.

Double Stars.

α (Σ **1110**, Castor). VII^h 26^m, N 32° 10′: 3, 3·5: 258°·8: 4″·7, 1830; D 241°·4: 5″·7, 1865; De 239°·3: 5″·6, 1871: bright white, pale white. Σ greenish. H calls it 'the largest and finest of all the double stars in our hemisphere;' its rapid motion first fully convinced ♅ of the existence of binary systems. Period not certain: H gives it 253, Sm, 240, Hind, 632, Jacob, 653 y. Excellent object for small telescopes. Huggins believes it may be receding from us about 25 miles per second; (*β* approaching us 49 miles.) Nearly 1° *s*, a little *f*, is a severe test, Poulkova Cat. 175. 6, 6·7: 345°·4: 0″·5, 1864; discovered independently by Bird with 12 in. silvered mirror, and seen by Buffham with 9 in. do. (With); orange, blue.

ε. VI^h 36^m, N 25° 15′: 3, 9·5: 94°·1: 111″: brilliant white, cerulean blue, 1831 [3 strongly yellow, 1849].

μ. VI^h 15^m, N 22° 35′: 3, 11: 89°: 80″: crocus yellow, bluish. [Tint of 3 very fine. 11 very small, 5½ in. 1863.]

γ. VI^h 30^m, N 16° 31′: 3: brilliant white. [With a low power, minute stars radiate from it every way; a pretty field.]

δ (Σ **1066**). VII^h 12^m, N 22° 13′: 3·5, 9: 196°·8, 1838; Se 200°, 1856: 7″·2: pale white, purple.

ζ. Triple. VI^h 56^m, N 20° 46′: 4, 8, 13: 355°, 85°: 90″, 65″: pale topaz, violet, grey. [13 a glimpse-star, 3$\frac{7}{10}$ in.]

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κ. VII^h 37^m, N 24° 41′: 4, 10: 231°·9: 6″: orange, pale blue.

38 (Σ **982**). VI^h 47^m, N 13° 21′; 5·5, 8: 171°·8: 6″, 1863; De 166°·3: 6″·1, 1863: light yellow, purple. Binary. Σ finds mags. var.

15. VI^h 20^m, N 20° 52′: 6, 8: 205°·4: 33″: flushed white, bluish, 1832; pale white, ash-coloured, 1852; Sestini orange, yellowish, 1845; Kn yellow, purple, 1872.

20 (Σ **924**). VI^h 25^m, N 17° 52′: 8, 8·5, 1833; Σ 6, 6·9, 1830: 209°·2: 20″: yellow, pale blue; Whitley both white, 1868. Field fine; 1½° *n p* γ.

61. VII^h 19^m, N 20° 31′: 7·5, 9: 110°: 60″: deep yellow, 1835; yellowish. [7·5 white, and no *comes* larger than 11 m. 1852, 1855. Kn 9 *not found*, 1861, 1871.] This pair points to another *n p*, Σ **1083**. 8, 9: 42°·4: 6″ 5: blue, bluish. 2° *s f* δ.

[H 264. VII^h 20^m, N 22° 25′: [8, 10, 1872:] est. 271°–272°: 35″, 1783: [orange, blue: colours very fine. It is about 40′ *n* of 63, a 6 m. star with a minute attendant, which is 2° *f* δ, a little *s*.]

(R. VII^h 0^m, N 22° 54′. Var. Secchi very remarkable spectrum at *max.* (+7 m.) containing bright lines.)

(U. VII^h 47^m, N 22° 21′. Var. 9—below 14. Baxendell and Kn have found *maximum* hazy.—1858, Nov. it increased 1½ m. per day!)

[Red star. VI^h 3^m, N 26° 3′: 8 m. Bird.] η. VI^h 8^m, N 22° 32′: 4m, has one ruddy star, Lalande 11734, *s p*, Birmingham; and two more, 6 and Lalande 11731, *n p*, Webb; within about 1°.

[GEMINI]

Clusters and Nebulæ.

1360 (M 35). VI^h 1^m, N 24° 21′. Beautiful and extensive region of small stars, a neb. to naked eye: how differently Lassell's 24 in. mirror shews it, his own words will tell:—'A marvellously striking object. No one can see it for the first time without an exclamation . . . the field of view, 19′ in diameter and angular subtense 53½°, is perfectly full of brilliant stars, unusually equal in magnitude and distribution over the whole area. Nothing but a sight of the object itself can convey an adequate idea of its exquisite beauty.' Sm observes that the stars form curves, often commencing with a larger one [elegant festoon near centre, starting with a reddish star; 9 in. spec.]: (see note on Sagittarius, *infra*). Between ε Gem. and ζ Taur. a little *n*; in a fine region. About ½° *s p*, just beyond a group of outliers, is 1351 (H VI 17), a faint dim cloud of very minute stars.

1549 (H VI 1). VII^h 31^m, N 21° 52′. Faint mass of very small stars; H 11–18 m. [beautiful, and in rich region, 9 in. spec.].

1532 (H IV 45). VII^h 22^m, N 21° 10′. H observed this object as a 9 m. star, 'with a pretty bright nebulosity, equally dispersed all around: a very remarkable phænomenon.' H describes it as an 8 m. star, 'exactly in the centre of an exactly round bright atmosphere 25″ in diameter.' Sm who rates it 7·5 m. says he 'could only bring it to bear as a burred star.' I was so much surprised at the result in my inferior telescope, that I cannot help supposing some temporary impediment to distinct vision at Bedford, for on coming accidentally across it in 1850, I found such a conspicuous nebulosity that I thought it was either damp on the eye-lens, or a telescopic

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comet; and in 1852 I entered it as 'a bluish nebulosity quite like a telescopic comet.' 1865, with 5½ in. I perceived a very faint trace of a brighter border *s* a little *f*. The E. of Rosse saw a marvellous object: a star surrounded by a small circular neb. in which, close to the star, is a little dark spot; this neb. is encompassed, first by a dark, then by a luminous ring, very bright, and always flickering. Buffham sees the dark ring with 9 in. 'With'; Key's 18 in. mirror shews 2 concentric bright rings, and the dark spot, 1868. It lies 2° *s f* δ.

HERCULES.

Some very fine telescopic objects mark this constellation.

Double Stars.

ζ (Σ **2084**). XVI^h 36^m, N 31° 50′: 3, 6: 190°: elong. 1835; 136°·9: 1″·2, 1842; 83°·8: 1″·3, 1852: yellowish white, orange. Most remarkable binary. Σ 23°·4 : 0″·9, 1826; single, 1828–31; 203°·5: 0″·9, 1834; Fletcher 59°·2: 1″·4, 1857; single, 9½ in. 1000, 1865; A. Clark double, 7 in., 1865; D 225°·1: 1″, 1866; Kn 206°·5: 1″, 1868; 183°·3: 1″, 1871. Sm's period 35 y; Plummer 36·06 y.

α (Σ **2140**). XVII^h 9^m, N 14° 32′: 3·5, 5·5: 118°·7: 4″·5: orange, emerald or bluish green. Sm calls it a 'lovely object, one of the finest in the heavens.' H makes 3·5 var. 3 to 4 m; Σ not, but finds 5·5 var. 5 to 7 m; A, not 5·5 but 3·5 var. in 66·4d; Baxendell in 88·5d. Apparently stationary.

ρ (Σ **2161**). XVII^h 19^m, N 37° 16′: 4, 5·5: 308°·9: 3″·7: bluish white, 1839, pale emerald; De 4 reddish white, 1853, 1855. Angle changing?

δ (Σ **3127**). XVII^h 10^m, N 25° 0′: 4, 8·5: 173°·9: 26″,

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1830; Kn 179°·6: 20″·2, 1866; 180°·3: 19″·3, 1871: greenish white, grape red, 1830–7–9; Σ green, ashy-white; Fletcher yellow, red, 1851; De yellow, blue, 1854–5; white, blue, 1855–6; Kn pale yellow, ruddy purple, 1871; [pale yellow, bluish green, 1850.] Binary?

μ (Σ **2220**). xvii^{h} 42^{m}, N 27° 48′: 4, 10: 241°·8: 30″: pale straw colour, cerulean blue. Apparently relatively fixed, with c. p. m.: if so, their real sizes must widely differ. 10 was found double, 10·5, 11, by A. Clark, 1856. D rapid binary, 60°·4: 2″, 1859; 77°·6: 1″·8, 1864; Buffham est. 0″·7, 1868. Missed at Dorpat and Poulkova.—OΣ 85°: 1″·1, 1866.

λ. xvii^{h} 25^{m}, N 26° 13′: 4·5^{m}: inserted for its curious colour, with my 3$\frac{7}{10}$ in. deep, dull orange. Towards this point the whole solar system, according to H and A, is moving.

110. xviii^{h} 40^{m}, N 20° 26′: 5, 16: 110°: 55″: pale yellow, dusky; *minim. visibile*, 1831. [5$\frac{1}{2}$ in. pretty steady, 1862.] Buffham easy, 6$\frac{1}{2}$ in. 'With' spec. 1868.

95 (Σ **2264**). xvii^{h} 56^{m}, N 21° 36′: 5·5, 6: 261°·8: 6″·1: light apple-green, cherry-red. Sm observes that 'this beautiful object presents a curious instance of difference in colour between components so nearly equal in brightness.' Se thinks red the larger, green the brighter. P Sm tints var. Macdonnell at Sydney, both golden yellow. Extremely pretty; to find it, mark, on Map, its configuration with α Herc. and α Oph.

κ^{1}, κ^{2} (Σ **2010**). xvi^{h} 2^{m}, N 17° 24′: 5·5, 7: 9°·7: 31″: pale yellow, reddish yellow.

23. xvi^{h} 18^{m}, N 32° 38′: 6, 9: 20°·1: 36″: white, violet, 1$\frac{1}{2}$° *s* of ν Cor.

42 (Σ **2082**) xv^{h} 35^{m}, N 49° 11′: 6, 12, 1835: 93°·5: 20″:

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orange, blue: a still minuter *comes*, 12 m. glimpsed with $3\frac{7}{10}$ in. 1851. 10 m. Birmingham, $4\frac{1}{2}$ in. 1871; with a little pair in field.

56 (Σ **2110**). XVI^h 50^m, N 25° 56′: 6·5, 13: 96°·1: 15″: light yellow, pale red. An 11 mag. *comes*, 170°: 540″. Very severe test, 5·9 in.—3 more minute stars.)

P XVII 200 (Σ **2194**). XVII^h 36^m, N 24° 35′: 6·5, 9: 9°·5: 16″·3: topaz yellow, purple. [A good low-power field *f*.]

100 [Σ **2280**. XVIII^h 3^m, N 26° 5′: 7, 7: 2°·8: 14″·1: pale white.

P XVII 300 (Σ **2245**). XVII^h 51^m, N 18° 21′: 7·5, 8: 114°·9: 2″·5: lucid white.

46 (Σ **2095**). XVI^h 40^m, N 28° 36′: 7·5, 10: 163°·8: 5″·1: pale white, sky blue.

[A conspicuous pair, 6, 7: flushed white, bluish, lies about $2\frac{1}{2}$° *n f* from β towards 51.]

[P XVI 125, 126. XVI^h 30^m, N 17° 20′: 7, 8.]

[Σ **2120**. XVII^h 0^m, N 28° 16′: 7, 9: 0°·2: 3″·1, 1836; De 272°·9: 3″, 1865; Kn 7, 10: 263°·3: 3″·9, 1871: red, blue; colours remarkable; Kn 7 tawny; De pale yellow; so 9 in. spec. 1871. Binary.]

[Σ **2079**. XVI^h 34^m, N 23° 15′: 7·1, 7·9: 90°·7: 16″·6.]

[Σ **2087**. XVI^h 37^m, N 23° 54′: 8·2, 8·2: 291°·4: 5″·9.]

(ν. XVII^h 54^m, N 30° 12′, 5 m., has a pair *f*, 8, 9: est. 270°: 20″. Birmingham.

[Pretty 8 m. pair, white, 25′ *n f* 5, XV^h 55^m, N 18° 8′: 6 m.]

Nebulæ.

4230 (M 13). XVI^h 37^m, N 36° 42′. Superb globular cl. lying $\frac{1}{3}$ from η towards ζ; finest of its class; just visible to

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naked eye. Halley discovered it in 1714; M was *sure* it contained *no stars*; but it is spangled with glittering points in a $5\frac{1}{2}$ f. achromatic, and becomes a superb object in large telescopes. H speaks of thousands of stars, 10 or 11 to 15 or 20 m. Sm calls it 'an extensive and magnificent mass of stars, with the most compressed part densely compacted and wedged together under unknown laws of aggregation:' H describes 'hairy-looking curvilinear branches' [well seen with 8 in. 'With' mirror]: E. of Rosse, who noticed this spiral tendency, perceived also 3 dark 'lanes' or rifts in its interior, beautifully seen by Buffham with 9 in. 'With' mirror. Huggins finds spectrum continuous, but red end wanting. (See 116 (M 31) And: and 826 (Ḣ IV 26) Erid: *antea.*) In Se's achr. the outliers, inconspicuous in ordinary instruments, fill a field of 8′. The aspect of this collection of innumerable suns is enough to make the mind shrink with a sense of the insignificance of our little world. Yet the Christian will not forget that, as it has been nobly said, HE took of the dust of this earth, and with it HE rules the universe!

The neighbourhood is beautiful with a low power.

4294 (M 92). XVII^h 13^m, N 43° 16′. Very fine neb. not equal to M 13; less resolvable; intensely bright in centre. In H's reflectors, a brilliant cl. 7′ or 8′ diam. Buffham, with 9 in. spec. found stars brighter and more compressed than in M 13, but blaze resolved by glimpses. Spectrum as M 13.

4234 (Σ 5 N). XVI^h 39^m, N 24° 2′. Plan. neb. 8″ diam.; discovered by Σ. [Very bright; small; not sharply defined; exactly like a star out of focus, bearing power well. 111 of $5\frac{1}{2}$ in. shewed a glow round it.) E. of Rosse intense blue. Se thought it resolved with a power of 1,500; but the

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spectroscope shews it gaseous. Rather more than 1° *s p* 51, 5 m.

4244 (H IV 50). XVI^h 43^m, N 47° 46′. Plan. neb. faint with $3\frac{7}{10}$ in. but beautifully grouped in a triangle with two 6 m. stars. Huggins finds continuous stellar spectrum.

HYDRA.

A very lengthy and not very interesting constellation to the unaided eye; but containing some telescopic work.

Double Stars.

ε (Σ **1273**). VIII^h 40^m, N 6° 54′: 4, 8·5: 198°·4: 3″·4, 1837; Talmage 213°·8: 3″·9, 1866: pale yellow, purple. Binary: Sm suggests in about 450 y.

10. XIV^h 38^m, S 24° 53′: 5·5, 7·5: 138°·4: 9″·8: deep yellow, reddish violet. Binary? 54 in Proctor's Atlas, after H.

τ^1. IX^h 23^m, S 2° 12′: 5·5, 8·5: 2°·9: 65″: pale white, dusky.

P VIII 108 (Σ **1245**). VIII^h 29^m, N 7° 4′: 6, 7: 24°·9: 10″·5: full yellow, flushed. Finely grouped with other stars, 1° *n p δ* (in the head).

P VIII 160 (Σ **1270**.) VIII^h 39^m, S 2° 8′: 7, 8: 258°·9: 4″·9: silvery white, smalt blue.

17 (Σ **1295**). VIII^h 49^m, S 7° 29′: 7·5, 7·5: 357°·8: 4″·5: white.—45′ ± *s*, pair, 7·5, 9·5: est. 170°: 1″·5. Burnham.

P IX 65, 64 (Σ **1347**). IX^h 17^m, N 4° 3′: 8, 9: 309°·8: 22″: white, 1836 [reddish white, grey or bluish, 1851].

P X 159. X^h 41^m, S 14° 56′: 8, 9: 10°: 32″: pale white, light blue. [This points to a much finer object, a triple star, Σ **1474**. X^h 41^m, S 14° 23′, all 7 to 8 m., and nearly in a line. $1\frac{1}{2}$ *n* of *ν*.]

[HYDRA]

[A pretty open 8 m. pair follows γ, about 1° distant.]

(R. XIII^h 23^m, S 22° 36′. Var. 4 m. to less than 10 m. in about 447 d.)

Nebula.

2102 (♅ IV 27). X^h 18^m, S 18° 0′. Plan. neb. 2° *s* of μ, resembling Jupiter, Sm says, in size, equable light and colour. I found it bright, a little elliptical *n p*, *s f*, of a steady pale blue light, bearing high powers. ♅ did not resolve it. Se, whose beautifully defining glass accomplishes marvels with 1,000, finds it an unique object; within a circular nebulosity it contains two clusters connected by two semicircular arches of stars forming a sparkling ring, with one star on the hazy ground of the centre. Huggins sees an oval ring surrounded by broad faint nebulosity; but its spectrum is that of gas, and the bright points cannot be solid matter.

LACERTA.

A small and not distinctly marked asterism.

Double Stars.

8^2 (Σ **2922**). Quadruple. XXII^h 30^m, N 38° 58′: 6·5, 6·5, 11, 10: two nearest 185°·5: 23″: two white, greenish, blue.

P XXII 65 (Σ **2894**). XXII^h 13^m, N 37° 7′: 6·5, 9: 193°·4: 15″·2: pale white, livid. Closely *f* 1, 5 m.

Clusters.

4773 (♅ VIII 75). XXII^h 10^m, N 49° 14′. Fine cl., quickly followed by beautiful field with 3 pairs.

[7. XXII^h 26^m, N 49° 37′, points out a noble field. 4, a 5 m. star, 1° *s p* 7, is a fine object, deep orange, with a blue attendant, in a rich field.]

LEO.

A fine constellation, the fore part of which is marked to the naked eye by a *sickle* composed of conspicuous stars. At the bottom of the handle, and very nearly in the pathway of the Sun, is the leader, Regulus, the Lion's Heart, the first of the list.

Double Stars.

α. x^{h} 1^{m}, N 12° 36′: flushed white. Σ and Se think a distant 8·5 m. attendant, which affords a beautiful contrast, is moving with it through space. Huggins finds in *α* a motion from our eye of 12 to 17 miles per second.

β. xi^{h} 42^{m}, N 15° 18′: 2·5, 8: bluish, dull red. Very wide. Probably receding from us, as *δ*.

γ (Σ **1424**). x^{h} 13^{m}, N 20° 30′: 2, 4: 103°·2: 2″·6, 1831; D 110°·3: 3″·2, 1865; Kn 112°·8: 3″, 1871: flushed yellow, ditto paler [deeper, 5½ in. 1860]; ♅ white, reddish white; Kn 4 cool grey green. Binary; period 1,000 y. or less? A very fine object. Schmidt thinks the neighbour, 40, var.

ι (Σ **1536**). xi^{h} 17^{m}, N 11° 15′: 4, 7·5: 87°·7: 2″·4, 1839; D 72°·1: 2″·8, 1865; De 72°·3: 2″·5; 1870: pale yellow, light blue [tawny, 9 in. spec. 1870.] Binary. [80, just divided, 1849.]

54 (Σ **1487**). x^{h} 49^{m}, N 25° 27′: 4·5, 7: 102°·7: 6″·2: silvery white, ash-coloured.

90 (Σ **1552**). Triple. xi^{h} 28^{m}, N 17° 31′: 6, 7·5, 9·5: 209°·1, 233°·9: 3″·5, 59″: silvery white, purplish, pale red.

49 (Σ **1450**). x^{h} 28^{m}, N 9° 19′: 6, 9: 158°·1: 2″·5: silvery white, pale blue; 1° *s f ρ*.

6. ix^{h} 25^{m}, N 10° 17′: 6, 9·5: 73°·6: 38″: flushed yel-

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low, pale purple, 1851; [deep orange, green, $3\frac{7}{10}$ in. 1851: 9·5 lilac, $5\frac{1}{2}$ in. 1862.]

P XI 9 (Σ **1517**). xi^h 7^m, N 20° 51′: 7·5, 7·5: 288°·6: 1″·2: faint yellow [elong? $3\frac{7}{10}$ in. 144]. Σ vars? Closely *s p δ*.

88 (Σ **1547**). xi^h 25^m, N 15° 5′: 7, 9: 319°·8: 14″·9: topaz yellow, pale lilac. Σ c. p. m.

83 (Σ **1540**). xi^h 20^m, N 3° 43′: 8, 9: 150°·8: 30″: silvery white, pale rose. Relatively fixed, c. p. m. Closely *n p τ*, 4 m., itself forming with P XI 71, 8 m. a fine pair (Σ 19 App. I), yellow, violet.

P X 67 (Σ **1431**). x^h 19^m, N 9° 26′: 8, 9·5: 64°·8: 3″, 1831; 67°·5: 3″·5, 1853: white, pale blue. Closely *f* 44, 6 m. orange, which is 2° *p ρ*.

P XI 91 (Σ **3072**). xi^h 24^m, S 6° 0′: 8, 11: 330°·2: 9″·5: creamy white, greenish.

P X 239 (Σ **1507**). xi^h 0^m, N 7° 50′: 8, 11·5: 164°·7: 8″·2: topaz yellow, cerulean blue. 11·5 very difficult, 80; steady, 144, so as to be a good comparative test; easily found; closely *f χ*, but not quite so near it as a larger star more *n* in the field.

[Σ **1434**. x^h 20^m, N 18° 40′: 8·5, 8·5: 269°·6: 6″·1: white.]

[R. ix^h 41^m, N 12° 2′. This var. lies a little *s f* in the field with 19, 7 m. Schönfeld gives it 5·3–6·3 m. at maximum; diminishing to 10 m. (11·5 Koch), with a very irregular period of about 312^d. Hind says, 'it is one of the most fiery-looking variables on our list—fiery in every stage from maximum to minimum, and is really a fine telescopic object in a dark sky, about the time of greatest brilliancy, when its colour forms a striking contrast with the steady

[LEO]

white light of the 6 m. a little to the *n*.' The known number of these mysterious objects is constantly on the increase, but a large proportion are too minute for general observation: those who can follow them find them endless sources of wonder. Many are intensely red; the times of increase and decrease are often strangely irregular or unequal; some are hazy, others quite sharp, at their minimum. Baxendell has noticed a singular tendency to collection into groups. Spectrum analysis alone holds out a distant hope of success in the enquiry into their constitution.

Nebulæ.

2377, 2373 (M 66, 65). XI^h 13^m, N 13° 43′. Two rather faint objects, elongated, but in different directions, in a low-power field, with several stars. 2377, *s*, rather the larger and brighter. Between ι and θ, a little *f*.

2207 (H I 18). X^h 41^m, N 13° 19′. Two faint neb^{æ}, *p* much the larger and brighter, with stellar nucleus. Sm mentions a neat little pair *n f* [well seen, 80]. Among the neb^{æ} in a round patch of 2° or 3°, in a region containing few stars.

LEO MINOR.

This small constellation contains several of H's neb^{æ}, but too faint for general interest. The following may be specified.

Nebula.

1713 (H I 200). VIII^h 45^m, N 33° 54′. H calls this a very beautiful object, 8′ × 3′: Sm saw a splendid centre [scarcely worth the search with $3\frac{7}{10}$ in., but in a very fine district, a little *p* the most *n* group of Cancer].

LEPUS.

A little asterism under the legs of Orion; so near the horizon that it can only be well seen on the meridian, and opportunities must not be thrown away.

Double Stars.

γ. v^h 39^m, S 22° 29′: 4, 6·5: 349°: 93″: light yellow; 6·5 pale green, 1832; flushed, 1852; [pale yellow, garnet, 1851.] There is a third star, 13 m: 345°: 45″ from 6·5. ℍ mentions another not found by Sm.

ι (Σ **655**). v^h 6^m, S 12° 1′: 4·5, 12: 336°·9: 15″: white, pale violet. I found 12 certain, 80; a glimpse star, 144; this seems to exemplify Sm's remark, that among very minute stars, the smallest sometimes shine with a keener light than those of larger apparent magnitude. Σ angular motion.

κ (Σ **661**). v^h 7^m, S 13° 6′: 5, 9: 359°·5: 3″·7: pale white, clear grey.

[R. IV^h 53^m, S 15° 1′. Var. discovered by Hind, 1845, who describes it as 'of the most intense crimson, resembling a blood-drop on the black ground of the sky; as regards depth of colour, no other star visible in these latitudes could be compared to it.' It was between 6 and 7 m. up to 1854. In 1855 Schmidt, who makes its period 448 d. considered it rapidly gaining light, but losing colour. In 1866 it was 9 m. but with 5½ in. of a magnificent crimson.—About 1° 40′ *s*, very little *p*, Birmingham sees a curious field with three pairs and one triple star.]

Nebula.

1112 (M 79). v^h 19^m, S 24° 38′. Tolerably bright with my 64, blazing in centre; higher powers shew it mottled.

[LEPUS]

Beautiful cl. in ♅'s 20 f. refl., nearly 3′ diam. 4° *s* a little *p* β, closely *f* a 6 m. star.

LIBRA.

S. declination combines with long days and late sunsets to give trouble in looking for the objects in this constellation, which are, however, well worth the pains.

Double Stars.

β. xv^h 10^m, S 8° 54′ : 2·5. Inserted for its beautiful pale green hue, very unusual among conspicuous stars: deep green, like deep blue, is unknown to the naked eye.

α^2 and α^1. xiv^h 44^m, S 15° 30′: 3, 6: 314° 3: 229″: pale yellow, light grey.

(51 Fl. See ξ Scorpii.)

P XIV 212. Triple. xiv^h 50^m, S 20° 48′ : 6, 8, 16: 272°·6, 320° : 10″·3, 20″ : yellow, dusky. 16 Sm's *minimum visibile.*

P XV 91. xv^h 24^m, S 19° 43′: 7·5, 9, 1832: 282°·6: 11″·8: bluish white, smalt blue. [9 very small, 1852.]

P XIV 70 (Σ **1837**). xiv^h 18^m, S 11° 5′: 7·5, 9·5: 325°·8: 1″·6: pale yellow, greenish. [almost in contact? $3\frac{7}{10}$ in. 250.]

P XIV 62 (Σ **1833**). xiv^h 16^m, S 7° 10′ : 8, 8 : 166°·8: 5″·2 : silvery white. 2½° *s f* ι Virg.

P XV 14. xv^h 7^m, S 17° 56′: 8, 9: 141°·7: 48″: silvery white, pale grey.

[Σ **1962**. xv^h 32^m, S 8° 22′: 6·3, 6·4: 187°·1: 11″·8: white.]

(P XV 150. xv^h 35^m, S 15° 36′: 7, 9·5: est. 90°: 2·5″. 30′ *s p* η. Burnham.)

[LIBRA]

(δ, xiv^h 54^m, S 7° 50′ is said by Schmidt to be var. 4·5 to 6 m. in 7·3 d.)

Cluster.

4083 (M 5). xv^h 12^m, N 2° 35′. Beautiful assemblage of minute stars (H 11–15 m.), greatly compressed in centre. M saw none. ♅ about 200 with 40 f. reflector. E. of Rosse curved exterior branches, seen also by Buffham, with 9 in. mirror. Closely *n p* 5 Serp. 5 m.

LYNX.

A troublesome constellation, excepting with an equatorial mounting, as there are few conspicuous leaders among a number of tolerably considerable stars, which are puzzling in the finder. The beauty of the pairs which it contains will, however, reward the observer's perseverance.

Double Stars.

38 (Σ **1334**). ix^h 11^m, N 37° 21′: 4, 7·5: 241°·6: 2″·8: silvery white, lilac.

14 (Σ **963**). vi^h 42^m, N 59° 36′: 5·5, 7: 50°: 1″, 1833: De 59°·5: 0″·7, 1863: golden yellow, purple. [not examined. Divided by Buffham, 9 in. spec. 1869.]

12 (Σ **948**). Triple. vi^h 35^m, N 59° 34′: 6, 6·5, 7·5: 154°·3, 305°·1, 1832; De 138°·6, 305°·8, 1863; 1″·6, 8″·6: white, ruddy, bluish, 1832, 1839, 1852; [7·5 ruddy, 1854; (so Hunt, 1863): elongated, 80; divided at times, 144.] Binary, with period of perhaps 700 y.

P VI 301 (Σ **1009**). vi^h 55^m, N 52° 57′: 6, 6·5, 1843: 159°·4: 3″: white. [little difference in mag. 1852.—so Σ 1830.]

[LYNX]

4 (Σ **881**). VI^h 11^m, N 59° 25′: 6, 7·5 : 90°·2 : 1″: white. [not examined.]

41. IX^h 20^m, N 46° 10′: 6·5, 8·5: 160°·8: 87″: bluish, 1832 [deep yellow, lilac, 1852]. Sm thinks P's 6·5 underrated. A 10 m. star forms a triangle.

39 (Σ **1340**). IX^h 14^m, N 50° 6′: 6·5, 9: 319°·5: 6″·2: lucid white, sapphire blue. 2½° *s p θ* Urs. Maj.

19 (Σ **1062**). Triple. VII^h 12^m, N 55° 32′: 7, 8, 8: 312°·4, 358°·2: 14″·6, 215″: white, two plum coloured.

20 (Σ **1065**). VII^h 12^m, N 50° 23′: 7·5, 7·5: 253°·3: 15″·2: silvery white.

P VI 174 (Σ **946**). VI^h 33^m, N 59° 34′: 7·5, 10: 134°·2: 4″: bright white, blue. Σ thinks 10 var. and this, Sm observes, 'awakens considerations of peculiar interest, it having been surmised that certain small acolyte stars shine by reflected light.' Exactly *p* 12.

P VIII 131 (Σ **1258**). VIII^h 34^m, N 49° 20′: 8·5, 8·5; 331°·5: 9″·8: white. About 2° *n p ι* Urs. Maj.

[40, IX^h 13^m, N 34° 56′ is a fine 4 m. star, orange, with an 8 or 9 m. companion, violet.]

[Σ **958**. VI^h 37^m, N 55° 51′: 6, 6: 256°·7: 5″·1: white, 1830. A fine pair, yellow, 1852, 1857. Easily visible with naked eye; most E. of a scattered group.]

(Σ **1338**. IX^h 13^m, N 38° 47′: 7, 7·2: 121°·1: 1″·8, 1839; Talmage 142°·5: 1″·7, 1866: white.)

LYRA.

For its size, one of the most remarkable constellations, full of beautiful fields, and adorned by one of the great leaders of the firmament,—the first of the following list.

[LYRA]

Double Stars.

α (Wega), XVIII^h 33^m, N 38° 40′, to my sight is inferior to Sirius only. ♅ and H have ranked Arcturus and Capella higher: probably differences of colour affect materially the estimates which different eyes form of magnitude *: a supposition entertained by Sm as well as by other great observers. Wollaston's experiments, from which he allowed Wega but $\frac{1}{9}$ of the light of Sirius, must surely have involved some fallacy. Humboldt thought it twinkled less than Arcturus and Procyon. Its colour is pale sapphire,—a lovely gem: its enormous real bulk is evident from its very minute and doubtful parallax. Huggins thinks that it is approaching us at 44 to 54 miles per second. A smalt-blue 11 m. attendant—135°·2 : 43″, 1830; Kn 151°·9 : 46″, 1865;—is a well-known test; my $3\frac{7}{10}$ in. sometimes shewed it in favourable weather: I have thought it easier with 80 than 144; De thinks it brighter than formerly: it must be looked for very near the rays of *α*, as there are other minute stars at greater distances in the field. It is said to have been easily perceived with $2\frac{13}{16}$ in., and with an $8\frac{1}{2}$ in. 'With' spec. less than 30^m after sunset. Buckingham and others, with 9 and $21\frac{1}{4}$ in. apertures, have seen 3 other closer and fainter *comites*. Gill one, 12 in. refl. 3″ or 4″, not the same? Penrose one, $5\frac{1}{2}$ in. achr. De La Rue one often suspected. Buckingham thinks them var.

β (Σ 39 App. I). XVIII^h 45^m, N 33° 13′. Var. 3·5 to 4·5 m. in about 12^d 21^h 47^m, two maxima and two unequal minima occurring within that time, in which Schmidt has recently

* The American astronomers at Harvard College, with the great 22 f. achromatic, have found that Wega surpasses Arcturus in photographic power no less than 7 times: no doubt from its different hue.

detected minor variations: its three companions, 8, 8·5, 9, with a minute neat pair, make up a fine field. Sm, 1834, marked β 'very white and splendid;' I found it, 1849, 1850, 1855, decidedly yellower than γ, which he calls at the same epoch 'bright yellow;' H and South call it white, 1824; Mädler pure white; Σ flava, 1835. γ, on the contrary, I saw white, or very pale yellow, 1850, 1855; $5\frac{1}{2}$ in. shewed both very pale, but β the yellower, 1862; Schmidt made them both whitish yellow, 1844–1855. Se finds in β (but with much difficulty) a spectrum like that of γ Cass. γ is a suspected var. being brighter than β.

ζ (Σ 38 App. I). XVIII^h 40^m, N 37° 28′: 5, 5·5, 1834 [more unequal, $3\frac{7}{10}$ in. 1850, 1855; as Sm, $5\frac{1}{2}$ in. 1862]: 149°·6: 44″: topaz, greenish.

ε^1, ε^2 (4, 5) (Σ **2382**, **2383**, 37 App. I). Double-double. XVIII^h 40^m, N 39° 32′: 5, 6·5 and 5, 5·5: 21°·9: 3″·3 and 152°·8: 2″·5, 1839; 19°·7: 3″ and 148°·1: 2″·5, 1853: yellow, ruddy; and both white. 'The naked eye,' Sm observes, 'sees an irregular-looking star near Wega, which separates into two pretty wide ones under the slightest optical aid. Each of these two will be found to be a fine binary pair.' So I see it, and probably most observers: ♅, however, Bessel at 13 years of age, and many others have divided it with the naked eye. There is little doubt of the rotation of each pair, ε^1 perhaps in about 2,000 y., ε^2 in half that time, and possibly both pairs round their common centre of gravity in something less than a million y. Between them lie three much smaller ones; one, 9·5 m (D), is obvious; two,—the *debilissima* of H,—are excessively minute, 13 m., on each side of the line joining ε^1 and ε^2: in very fine weather I have had glimpses of

one, and suspicions of the other, with $3\frac{7}{10}$ in. an aperture for which they are excellent tests. Grover has found them alternately var.; so Squire. There are about 6 or 7 * other extremely faint points in the group, some of them very difficult tests, though Holden has seen several with 3 in. achr. Σ surmised alternately variable light in the components of ϵ^2; and saw 6·5 of ϵ^1 bluish; so De. This most beautiful object, which I have seen well with $2\frac{1}{4}$ in. lies $1\frac{1}{2}°$ *n f α*.

η (Σ **2487**). XIX^h 9^m, N 38° 55′: 5, 9: 84°·8: 28″: sky-blue, violet, 1834; [yellow, greenish or bluish, in my own $3\frac{7}{10}$ in. and Bishop's 7 in. achr. 1849–50; 5 pale yellow, $5\frac{1}{2}$ in. 1862; Σ blue, 1830. A low-power field includes two other small pairs, *s p*, and *f*; Birmingham adds a third.]

17 (Σ **2461**). XIX^h 3^m, N 32° 18′: 6, 11: 329°·9: 3″·6: light yellow, cerulean blue. [About $2\frac{1}{4}°$ *n* are two wide pairs in a large sprinkled field.]

P XVIII 151 (Σ **2362**). XVIII^h 34^m, N 35° 56′: 8, 9: 180°·2: 3″·8: pale white, lilac. 3° *s* of *α*.

P XIX 13 (Σ **2472, 2473**). Quadruple. XIX^h 4^m, N 37° 42′: 8, 11, 9·5, 12: 337°, 350°: 18″·5, 75″ (9·5, 12: 294°: 5″): bright yellow, pale grey, greenish, dusky. 12 var.? should be watched. There is a very minute star between the pairs.

[δ^2 and δ^1. XVIII^h 49^m, N 36° 48′: 4, 5: fine orange, white. Glorious field for low powers.]

[*θ*. XIX^h 12^m, N 37° 54′: 5, 10: yellow, blue, is in a fine field.]

[Σ **2372**. XVIII^h 37^m, N 34° 37′: 6·7, 8·2: 84°·2: 25″: white, bluish. D triple, 12m. 2° *n p β*.]

* Astronomical Register, cix. 15.

[LYRA]

[B. A. C.* 6468 (Bode 91). XVIII^h 50^m, N 33° 48′: 7, 8·7 (A): 350°·2: 45″ (Kn): deep yellow, blue: beautiful miniature of β Cyg. Two other very minute stars in the group. 7 is a very difficult double, Poulkova Cat. 525.—D 5, 11: 124°·5: 1″·9.]

Nebulæ.

4447 (M 57). XVIII^h 49^m, N 32° 52′. The only annular neb. accessible by common telescopes; fortunately easily found ⅓ of the distance from β towards γ. It is somewhat oval, and bears magnifying well: its light I have often imagined fluctuating and unsteady, like that of some other plan. neb$^{\mathrm{a}}$: but this is of course an illusion, arising probably from an aperture too small for the object. The E. of Rosse thought it resolvable, and saw several wisps or appendages within and without it. Se reduced it to minute stars, glittering like finely powdered silver. Chacornac also resolved it with the great Foucault silvered mirror of 2½ f. Nevertheless the spectroscope of Huggins demonstrates it to be luminous gas. [A minute star (H 11 m.) *f*, 5½ in.]

4485 (M 56). XIX^h 11^m, N 29° 57′. Faintish, perhaps resolvable with 3$\frac{7}{10}$ in. in a fine field and rich region, between 3° and 4° *n p* β Cyg. Sm sees it as 'a globular cluster in a splendid field:' H 11—14m. A strange contrast to the last.

MONOCEROS.

A constellation inconspicuous to the unaided eye, but rich in groups and clusters from its position in a brilliant part of the Galaxy.

* British Association Catalogue.

[MONOCEROS]

Double Stars.

8 (Σ **900**). VI^h 17^m, N 4° 39′: 5·5, 8: 23°·8: 12″·9: golden yellow, lilac. Birmingham a faint *comes*, 12: 50°? 60–70″? Glorious low-power field.

29 (Σ **1190**). Triple. VIII^h 2^m, S 2° 36′: 5·5, 13, 9: 104°·7, 243°·8: 30″, 67″: light yellow, grey, pale blue. 13 more like 10 or 11 to me, 1851, 1855, 1856, 1872 (9 in. spec.); yet H and South missed it. Can it be var? Σ calls it *his* 11·7, 1830; yet saw it in a 5 f. instrument.

15 (Σ **950**). VI^h 34^m, N 10° 1′: 6, 9·5: 206°·2: 2″·5: greenish, pale grey. A blue *comes* 15m. which I saw steadily with 5½ in. 1864 (like 12 or 13m. 9 in. spec. 1872). I found one still smaller and more remote with 5½ in. *n p*. Three other pairs form an irregular transverse line beneath it. A fine group lies *s*.

11 (Σ **919**). Triple. VI^h 23^m, S 6° 57′: 6·5, 7, 8: 130°·3, 121°·6: 7″·2, 9″·6 (7 and 8, 102°·3: 2″·8): white, two pale white. H, the discoverer in 1781, calls this 'one of the most beautiful sights in the heavens.' Notwithstanding the striking appearance of connection, motion has not been detected here.

P VII 116 (Σ **1097**). VII^h 22^m, S 11° 18′; 7, 9·5: 315°: 20″: yellow, violet. Clear blue 14 m. star *s*.

P VIII 81 (Σ **1233**). VIII^h 21^m, S 2° 5′: 7, 11: 325°: 15″: pale topaz, violet.

P VI 104, 105. VI^h 20^m, N 0° 32′: 7·5, 8·5: 151°·5: 68″: topaz yellow, plum coloured. Σ divides, Sm elongates 8·5 (Σ **910**). A low-power field includes 77 Or., a fine 6 m. yellow star, with this pair *n p*, and another *s p*: a noble spectacle.

(3. V^h 56^m, S 10° 36′: 5·5, 10; Burnham; Kn 356°·1: 1″·8.)

[MONOCEROS]

(4. VI^h 2^m, S 11° 7′: 6, 11; Burnham; Kn 178°·6: 3″·4; with another *comes* 11·5: 244°·1: 10″.)

[31, P VIII 151. VIII^h 37^m, S 6° 46′: 5·5, 8; (7, 9 on S. D. U. K. Map; A gives 5 m.): fine yellow, beautiful blue.]

[Region *p* 13, VI^h 26^m, N 7° 26′, very rich in wide pairs.]

[5, VI^h 9^m, S 6° 14′, is a fine orange star.]

(Red star. VII^h 16^m, S 20° 40′: 9 m.)

Clusters.

1424 (H VII 2). VI^h 24^m, N 5° 2′. Beautiful; visible to naked eye; including 12, 6 m. yellow; and many 7 and 8 m. stars: the smallest (14 m.) run in rays.

1483 (M 50), VI^h 57^m, S 8° 9′. Brilliant cl. straggling, H says, to 30′; in a superb neighbourhood, where the Creator has

'—— sowed with stars the heaven thick as a field.' *

1465 (H VI 27). VI^h 45^m, N 0° 37′. Bright Galaxy cl. resembling three arms of a cross.

1637 (H VI 22). VIII^h 7^m, S 5° 24′. Group of pretty uniform 9 m. stars.

1415 (10). VI^h 22^m, S 4° 41′. This 6 m. pale yellow star is the *lucida* of an elegant group: and the Galaxy throughout this constellation well repays the trouble of sweeping.

OPHIUCHUS.

An extensive region, somewhat barren to the eye, but attractive to the telescope.

* Milton.

[OPHIUCHUS]

Double Stars.

λ (Σ **2055**). XVI^h 24^m, N 2° 16′: 4, 6: 351°·2: 1″, 1834; De 25°·3: 1″·5, 1865; 28°·7: 1″·5, 1871; yellowish white, smalt blue; D 6 white, greenish white, deep yellow, pale yellow. A beautiful object: binary; Hind's period 95·88 y.

67. XVII^h 54^m, N 2° 56′: 4, 8: 143°·6: 55″: straw-colour, purple. (At a short distance *p*, a little *s*, must be H's 'very fine orange star,' 7·5 m.)

36. XVII^h 7^m, S 26° 24′: 4·5, 6·5: 226°·1: 5″·2, 1831; 213°·8: 4″·6, 1857: ruddy, pale yellow, 1831, 1835, 1839, 1842 [golden yellow, 1854, 6·5 rather deeper ?]. Sm says 'the principal star is thought to be variable, though I have always seen it as now registered.' [1854, nearly equal, about 6·5, Sm's smaller perhaps rather the larger.] A 7·5 m. star lies near it. 36 is in orbital movement, with a period of perhaps 200 y., and also, strange to say, has the same proper motion with 30 Scorp. more than 13′ distant, so as to lead to the impression that, in Sm's words, 'while in itself a singular revolving binary system, it is accompanying another and a most distant object in an *annus magnus*, to contemplate the period of which makes imagination quail.'

70 (Σ **2272**). XVII^h 59^m, N 2° 32′: 4·5, 7: 136°·4: 5″·4, 1830; 119°·7: 6″·8, 1847; Kn 100°: 5″, 1867, 94°·9: 4″·3, 1871: purplish. P Sm thinks 7 var. in colour. Binary, revolving in about 80 y. (Jacob 112, Encke 74, Schur 94 y. at a distance 30 times that of Sun;) but with movements so singular that Jacob suspects disturbance from a third invisible companion. H observes that the rings around its telescopic image 'seem to have something peculiar. They are thin, and extend further than in general;' on another occasion he

remarks, in measuring it, 'Difficult, owing to the rings and appendages. N.B. I always find this star difficult from the above cause.' [3 minute *comites*, 9 in. spec. 1871.]

τ (Σ **2262**). XVII^h 56^m, S 8° 11′: 5, 6: 214°·5: 0″·5, 1838; Se 248°: 1″·6, 1866: pale white. Binary; 130 y? Σ single, 1825. A companion, 10, light blue, 115°: 82″, 1838.

ρ.* XVI^h 18^m, S 23° 8′: 5, 7·5: 3°·1: 3″·8: pale topaz, blue. Finely grouped with two 8 m. stars, 3° *n* a little *p* α Scorp.

39. XVII^h 10^m, S 24° 9′: 5·5, 7·5: 356°·2: 12″·1: pale orange, blue. Vertical near meridian; beautiful. Not very distant, XVII^h 23^m, S 21° 16′, was the Great New Star discovered by Möstlin, Kepler's scholar, in 1604; at first surpassing Jupiter and even rivalling Venus, but totally vanishing in 1¼ y. 39 is easily found, 1° *n p* θ.

73 (Σ **2281**). XVIII^h 3^m, N 3° 58′: 6, 7·5: 260°·5: 1″·7, 1834 [elong? 1850]. Se 255°·1: 1″·4, 1855: silvery white, pale white. Binary?

53 (Σ 34 App. I). XVII^h 28^m, N 9° 41′: 6, 8: 192°·5: 41″: greyish, pale blue; D 6 light yellow. 3° *s* of α.

19 (Σ **2096**). XVI^h 41^m, N 2° 18′: 6·5, 10, 1834; 92°·9: 22″: pale white, livid. [10 under-rated, 1850, 1857.] Fine low-power field.

P XVI 270 (Σ **2114**). XVI^h 56^m, N 8° 38′: 7, 8: 137°: 1″·5, 1832; Morton 147°·4: 1″·3, 1859: white. In a line carried from ι through κ as far again.

61 (Σ **2202**). XVII^h 38^m, N 2° 38′: 7·5, 7·5: 93°·9: 21″: silvery white, 1833. [*p* considerably the larger, 1850; a

* D doubts if rightly lettered. It is Fl. 5, or *g* (mistaken for ρ?).

little larger, 9 in. spec. 1871. Fletcher, 6, 7: yellow, 1851. Closely *p* γ, and 2° nearly *s* from β, a fine specimen of a pale yellow star.]

[Σ **2166**. XVII^h 22^m, N 11° 30′: 5·6, 7·4: 283°·2: 27″·5: white, bluish.]

[Σ **2191**. XVII^h 33^m, S 4° 54′: 7, 8: 268°·2: 26″·5: white. 2° *s f* M 14.]

[21. XVI^h 45^m, N 1° 26′: 6 m. yellow, (very close double, 0″·8 in Poulkova Catalogue) has a wide 8, 9 m. pair in field.]

[About XVII^h 43^m, N 5° 1′ is a pretty pair, 7·5, 10: est. 225°: 20″: pale yellow, pale blue.]

[Temporary. XVI^h 52^m, S 12° 41′, about 3° *n p* η. Hind's New Star, 5 m. 1848, April 28,* which afterwards faded to 11 m. but may yet blaze out again: it was orange, with flashes of red, a colour occasionally noticeable.]

(Red Star. XVII^h 48^m, N 1° 47′: 9 m. H.)

Clusters and Nebulæ.

4346 (M 23). XVII^h 49^m, S 18° 59′. Grand low-power field.

4256 (M 10). XVI^h 50^m, S 3° 55′. Bright resolvable neb. H 11—15 m. E. of Rosse tendency to curved branches. A beautiful group lies *f*; *lucida* bright orange.

4238 (M 12). XVI^h 40^m, S 1° 44′. Resolvable; H 10—16 m. Lord Oxmantown slightly spiral; finely grouped.

4264 (M 19). XVI^h 55^m, S 26° 5′. Large; fairly bright; but very low.

4315 (M 14). XVII^h 31^m, S 3° 10′. Large; glimpses of

* Airy rated it fully 5 m. May 9, 4 m. May 10, sinking to 6 m. May 18.

[OPHIUCHUS]

resolution; effected by H with 20 f. refl. (H 15 or 16 m. 'the finest star-dust.')

4287 (M 9). XVII^h 11^m, S 18° 23′. Small, apparently resolvable: 'a myriad of minute stars, clustering into a blaze in the centre, and wonderfully aggregated with numerous outliers' (Sm). H 14 m.

[About XVII^h 38^m, N 5° 40′ closely *n f* β, is a bright group, in appearance evidently a *family*: among them is a pair, 7, 9: pale blue, blue.

ORION.

The finest constellation in the heavens, equally remarkable for telescopic interest and obvious brilliancy; fortunately its position is very suitable for English observers, as it comes to the meridian in winter, and attains a sufficient, but not an inconvenient, altitude.

α (Betelgeuze), V^h 48^m, N 7° 23′, is irregularly variable. H, the discoverer, found it alternately above β (Rigel), and below α Tauri: from 1839, Nov. 26 to 1840, Jan. 7, losing nearly half its light: afterwards its changes were much less conspicuous till 1849. 1852, Dec. 5, Fletcher thought it brighter than Capella, which he rated clearly above Wega, so that it was then the brightest star in the N. hemisphere. He also saw it nearly approaching those stars, 1865, Dec. 25. When brightest, Huggins and Miller find that a group of dark lines fades out of its spectrum, which is remarkable, like that of β Pegasi and the ruddy variables, for the *extreme faintness of the lines of hydrogen.* Huggins thinks it may be receding from us 22 miles per second: Lassell says of it, 'a most beautiful and brilliant gem! Singularly beautiful in colour, a rich

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topaz; in hue and brilliancy different from any other star I have seen.' Look at α and β alternately to appreciate the contrast. Less than $\frac{1}{2}^{\circ}$ *s* is a pretty open 9·5 m. pair; Birmingham.

Double Stars.

β (Σ **668**). $v^h\ 8^m$, S 8° 21′: 1, 9: 199°·4: 9″·5: pale yellow, sapphire blue (H pale red; so Kitchener). I see always a blue tinge in the great star, resembling that of Wega; Σ however gives yellowish white; Fletcher yellow. Huggins supposes it may be receding from us 15 or more miles per second. A beautiful object and fair test for a pretty good telescope; but from its low altitude often blotted with vapour. Birmingham has seen 9 distinctly with $4\frac{1}{2}$ in. achr. just before sunset; and Burnham has detected it with $1\frac{1}{2}$ in. in the sky of Chicago.

δ (Σ 14 App. I). $v^h\ 25^m$, S 0° 24′: 2, 7: 359°·9: 53″: pale white, flushed white, 1850 [2 beautiful pale green, 1850; white or pale yellow, 1851]. This star nearly marks the equator.

ζ (Σ **774**). Triple. $v^h\ 34^m$, S 2° 1′: very large 3, 6·5, 10: 148°·8, 7°·8: 2″·5, 56″: yellow, flushed blue, grey. 6·5, singularly missed by H, and discovered by Kunowsky, seems of some nondescript hue, about which observers cannot agree. Σ uses a specially manufactured word, 'olivaceasubrubicunda.'

ι (Σ **752**). Triple. $v^h\ 29^m$, S 6° 0′: 3·5, 8·5, 11: 141°·7, 102°·8: 11″·5, 49″: pale white, bluish, grape red. Field very fine. [A glow with $5\frac{1}{2}$ in. around this group, which E. of Rosse finds to occupy a singular dark opening encompassed by nebulous matter.]

λ (Σ **738**). $v^h\ 28^m$, N 9° 51′: 4, 6: 43°: 4″·5: pale

yellow, purplish. [A very minute *comes* with 5½ in. not in Sm, but in Σ and Se. Matthews with 4½ in. achr.—Field very fine.]

σ (Σ **762**). Triple. v^h 32^m, S 2° 40′: 4, 8, 7: 84°·2, 60°·8: 12″·5, 42″: bright white, bluish, grape red, 1832, 1850 [4 yellow, 1851; 8 ruddy, 9⅓ in. spec. 1869]. An 11 m. star *p* 4 has escaped some of the first observers, though very plain now. A beautiful little triangle *p*, 8·5, 9, 8: dusky, white, pale grey, with a smaller *comes*, and two minute stars between the groups. Good light-test for 4 in. Matthews sees 5 other feebler companions, with 4½ in. achr.

32 (Σ **728**). v^h 24^m, N 5° 51′: 5, 7: 206°·2: 1″, 1839: bright and pale white. Closing; Kn with 7⅓ in. achr. in contact, and generally ill-defined, 1866; Bird barely separated, 10 in. spec. 1872. It lies *f* γ, a little *s*.

23 (Σ **696**). v^h 16^m, N 3° 25′: 5, 7: 27°·9: 32″: creamy white, light blue [a beautiful colour]. 3° *s* of γ, a little *p*.

ρ^1 (Σ **654**). v^h 6^m, N 2° 42′: 5, 8·5, 1835 [8·5 very small, 1849, 1856]: 61°·8: 6″·8: orange, smalt blue.

[*η*. v^h 18^m, S 2° 31′: 4, 5: 87°: 1″: white, purplish, D, 1848; Kn 89°·8: 1″, 1866. Fine test, but low, discovered by D. 5½ in. 212 sometimes split it. Buffham divides it with 4½ in. of 9 in. spec.]

[ψ^2. v^h 20^m, N 2° 59′: 5·5, 11: 322°·3: 2″·8: yellow, fine blue. Discovered by Kn, 1863; well seen, 9⅓ in. spec. 212. A little *s p* is Σ **712**, 7, 9: 45°·4: 3″·1: very white.]

52 (Σ **795**). v^h 41^m, N 6° 25′: 6, 6·5: 199°·9: 1″·8: pale white, yellowish. Σ tints reversed, and c. p. m. [In contact, 80, neatly split, 144: excellent test, readily found, about 2° *s p α*. Minute *comes*, *n* a little *f*, 9⅓ in. spec.]

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33 (Σ **729**). v^h 24^m, N 3° 12′ : 6, 8 : 25°·8 : 2″ : white, pale blue. Between γ and ζ, nearer γ.

P V 84 (Σ **708**). v^h 18^m, N 1° 48′ : 8, 10 : 322°·5 : 2″·6: silvery white, grey.

[ψ^1, *p* a little *s*, is in a fine field: about 50′ from this *s p* are two pairs, P V 67, orange, blue; and Σ **700**, 8, 8·2: 5°·3 : 4″·5 : white.]

P IV 278, 279 (Σ **630**). iv^h 55^m, N 1° 25′: 8·5, 9: 49°·3 : 13″·7 : silvery white, pale blue. [1° *f* π^6, 5 m.]

P IV 258 (Σ **622**). iv^h 51^m, N 1° 28′: 8·5, 9, 1833; Σ very nearly equal, 1830, 1833: 180°·4: 2″·4: white, pale grey. This beautiful object may be binary. Closely *s p* π^6.

[Σ **747**. v^h 29^m, S 6° 5′: 5·6, 6·5 : 223°·1 : 36″: yellowish, ashy. [In group of ι, *s p*.]

[31 (Σ **725**). v^h 23^m, S 1° 12′: 5·8, 11 : 87°·5 : 12″·7 : 5·8 high gold colour; [11 light-test, easy with 9⅓ in. silver.]

[Σ **750**. v^h 29^m, S 4° 27′: 6, 8 : 59°·2 : 4″·3 : white, ashy.]

[Σ **627**. iv^h 54^m, N 3° 25′ : 6·3, 7 : 260°·3 : 21″: white.]

[Σ **790**. v^h 40^m, S 4° 10′ : 7, 9·3 : 89°·1 : 6″·8 : orange, blue.]

[Σ **809**. v^h 44^m, S 1° 28′ : 7·7, 8·8 : 101°·2 : 26″: yellow, ashy.]

[Σ **757**. v^h 31^m, S 0° 19′: 8, 8·2 : 239°·8 : 1″·7 ; followed by Σ **758**, 8·5, 9 : 297°·7 : 11″·1 : all very white : another 8 m. *p*. Pretty group, *n* a little *f* ϵ, a pale green star, which has a little open pair, 9, 10 ms. *n* a little *p*.

[Σ **859**. vi^h 3^m, N 5° 41′ : 8, 8·5 : 249° : 31″ : yellowish, white.]

(Σ **895**. vi^h 14^m, N 5° 48′ : 8, 10; H 55° : 30″ : 9, 9·5 : full ruby red, fine green by contrast.)

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[About v^h 30^m, N 3° 40′ are a double and triple star in the same field.]

[A little pair forms a triangle *s* with *α* and 52. Birmingham.]

[Red Star. IV^h 59^m, N 0° 59′. 6·5 m. Lalande.]

[S. Var. Red.+v^h 23^m, S 4° 48′, 9? to 12? m. period not determined; centre of little triplet, 11, 11·5 ms. in large triangle; sweep 6⅓^m W from minute pair 10′ *n* of 42.—Webb, 1869. Dec. 25.]

Clusters and Nebulæ.

1184 (H 362). v^h 29^m, S 4° 26′. Brilliant field, containing Σ **750**, *supra*, and Σ **743**, 278°·9 : 1″·8. A grand neighbourhood: sweep well over the whole space from 42 to *ι*.

1361 (H VIII 24). VI^h 1^m, N 13° 59′. Triangular cl. containing pair, 7·5, 8·5 : 2″·4 : lucid white. 1° *s* of *ν*. 'These gatherings, occurring indifferently upon the *Via Lactea* and off it, awaken still more our admiration of the stupendous richness of the Universe, in every department of which there appears such a profusion of creation, if we may so express ourselves of the works of the ALMIGHTY, in which our utmost ken has yet never detected any redundancy, much less anything made in vain.' (Sm.)

1179 (M 42). v^h 29^m, S 5° 29′. The GREAT NEBULA IN ORION, one of the most wonderful objects in the heavens; readily visible to the naked eye.* The telescope shews an irregular branching mass of greenish haze, in some directions moderately well defined where the dark sky penetrates it in deep openings; in others melting imperceptibly away over

* It was strangely missed, as Humboldt says, by Galileo, who paid great attention to Orion. Cysatus compared it telescopically with the comet of 1618.

such an extent that Se, by moving his telescope rapidly to gain full contrast, has traced it in singular convolutions, and with a considerable break near σ, through $5\frac{1}{2}°$ of Dec. and $4°$ of RA,—from ζ to 49, and probably to H V 38—a prodigious diffusion. Bond II also found it encompassed by a distant nebulous loop; and in many parts detected about 20 curved wreaths, referred to a spiral structure. Its real nature was long a profound mystery. It resisted H's 40 f. reflector, in which it was the first object viewed, and, together with that in Andromeda, suggested to him the widely-discussed Nebular Hypothesis, which would see here an unformed fiery mist, the chaotic material of future suns. H found but the aspect of 'a curdling liquid, or a surface strewed over with flocks of wool, or the breaking up of a mackerel sky.' The E. of Rosse, with his 3 f. reflector, Lassell, with his 2 f. speculum in the Maltese sky, could advance no further: it was long believed that the 6 f. mirror of the E. of Rosse had lifted the veil, and distinguished in some places its starry composition; Bond, too, arrived at the same conclusion; and Se with smaller, but very perfect means, thought he could detect the glittering 'star-dust.' Yet, though this would imply a permanent form, there were strange discrepancies in the drawings by the best hands. H in England, the same observer at the Cape of Good Hope, Bond, Lassell, Liapounov with a $9\frac{1}{2}$ in. achr. at Kazan, OΣ at Poulkova, all differed in various ways; the latter even believed that the brightness of the central part was in a state of continual variation: and the subsequently published labours of Rosse, Lassell, and Secchi are far from correspondent in detail. All this is strange; and the spectrum-analysis of Huggins has only added to the wonder, by exhibiting it as a mass of incandescent gases, probably nitrogen and

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hydrogen! * In the densest part, four stars,—6, 7, 7·5, 8 m.†—form a trapezium. Sm gives their colours pale white, faint lilac, garnet, reddish; and Mädler thinks their connection is shewn by a common movement in space. Burnham has seen them with 1½ in., in the Chicago sky. Σ in 1826 discovered a fifth star, which is believed to have become visible only of late years, and it may be brightening, as it has been seen with 3⁸⁄₁₀ in., and it has been said, even with 2⅞ in. H added a 6th still smaller, 1830, Feb. 13, with South's 11¾ in. achr. Both have been thought var. De La Rue has seen both with a beautiful 4⅛ in. achr.: Burnham with 3¾ in. Two or three other most minute points have occasionally been detected. Salter, 9 or 10, with 12 in. (Bird) silvered mirror. OΣ thinks that several of them are subject to change, and remarks that 'the existence of so many variable stars on such a small space in the central part of the most curious nebula in the heavens must of course induce us to suppose these phænomena intimately connected with the mysterious nature of that body.' A considerable aperture will shew how beautifully one large star, nearly opposite the great dark opening, is encompassed by a spiral mass of haze. Clear weather must of course be chosen, and the lowest power which will bring out the trapezium is most likely to give a satisfactory contrast with the exterior darkness.

1267 (M 78). $v^h\ 40^m$, 0° 0′. Singular 'wispy' neb. well

* Rerum natura sacra sua non simul tradit. Initiatos nos credimus; in vestibulo ejus hæremus. Illa arcana non promiscue nec omnibus patent, reducta et in interiore sacrario clausa sunt: ex quibus aliud hæc ætas, aliud quæ post nos subibit, dispiciet. Tarde magna proveniunt.—SENECA, *quoted by Humboldt.*

† D remarks that they should be numbered θ^1, θ^2, &c. in order of R A, not of brightness.

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defined *n*, enclosing a pair 8·5, 9 : 32° : 45″, 1836 [stars much smaller, 1850, 1856, 1864].

PEGASUS.

A constellation easily recognized by the great square * which three of its principal stars form with that in the head of Andromeda.

Double Stars.

ε. xxi^h 38^m, N 9° 17′ : 2·5, 9 : 324°·3 : 138″ : bright yellow, blue lilac. This object, when near the meridian, well exhibits a phænomenon noticed by H,—the pendulum-like oscillation of a small star in the same vertical with a large one, when the telescope is swung from side to side ; this he thinks is due to the longer time required for a fainter light to affect the retina, so that the reversal of motion is first perceived in the brighter object. I have seen this strikingly in δ and ζ Orion. and δ Herc.

1. xxi^h 16^m, N 19° 15′ : 4, 9 : 310°·8 : 36″ : deep yellow, lilac blue. 4 said to be var. C. p. m. ?

κ (Σ **2824**). xxi^h 39^m, N 25° 0′ : 4, 13, 1836 [more like 11, 1852 ; 13, 1871, 9 in. spec.] : 310° : 12″; De 303°·9 : 11″·6, 1864 : pale white [yellowish, 1871], purple. Good light-test.

π^1. $xxii^h$ 3^m, N 32° 33′ : 5 : yellow, forms a grand pair with π^2, 4 m. [yellow.]

37 (Σ **2912**). $xxii^h$ 23^m, N 3° 46′ : 6, 7·5 : 116°·8 : 1″·3, 1835 : white. Sm binary, in about 500 y. Jacob doubts it. [single, 1854.] Se 117°·6 : 0″·7, 1857.

3 (Σ 56 App. I). xxi^h 31^m, N 6° 2′ : 6, 8 : 349°·5 : 39″ : flushed white, greyish : P Sm thinks colour of 8 var. Another very pretty pair in field, 8″ apart.

* Within this area A's *Uranometria Nova* contains barely 30 naked-eye stars. Schmidt, in the sky of Athens, counted 102.

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33. XXII^h 17^m, N 20° 12′: 6·5, 8: 340°·8: 58″: yellowish, pale grey. Σ c. p. m. 6·5 has a 10 m. attendant at 2″·7 (Σ **2900**), which I could not see, 1850. This object is the leader of a line of 6 similar stars.

P XXII 306 (Σ **2978**). XXIII^h 1^m, N 32° 7′: 7, 8·5: 146°·4: 8″·5: bright white, sapphire blue, 1833; Slack, aquamarine, tawny, 1865. [Several little pairs similar to each other lie dispersed in this region.]

P XXIII 216, 217 (Σ **3044**). XXIII^h 46^m, N 11° 12′: 8·5, 8·5: 102°: 18″·5: silvery white, 1834; so Σ 1830, yet I saw them white, pale blue, 1850–1, not quite alike, 1856. The mags. I also found obviously unequal, *p* the smaller: I was not then aware that Σ had found the difference vary a whole m. The period of this change should be investigated.

[η. XXII^h 37^m, N 29° 33′: 3 m. has, like ε, a bluish 10 m. companion, but the large star is paler yellow. Schmidt thinks its tint var. more white or red in different years.]

[Σ **2878**. XXII^h 8^m, N 7° 20′: 6·5, 8: 130°·8: 1″·4: white; a pretty object.]

[Σ **2799**. XXI^h 23^m, N 10° 31′: 6·6, 6·6: 332°·9, 1831; De 317°·6, 1863: 1″·4: yellowish. Beautiful.]

[Σ **2804**. XXI^h 27^m, N 20° 8′: 7, 7·5: 316°·9, 1831; De 324°·5, 1864: 2″·7; Kn 3″, 1871: white.]

[Σ **2848**. XXI^h 52^m, N 5° 19′: 7·2, 7·5: 54°·9: 10″·4: white, ruddy. I did not see this hue, 9 in. spec. 1871.]

Nebula.

4670 (M 15). XXI^h 24^m, N 11° 35′. Bright and resolvable (H 15 m.), blazing in centre: a glorious object with 9⅓ in. 'With' mirror. Very fine specimen of a completely insulated

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cl. discovered by Maraldi, 1745. Buffham with 9 in. spec. finds a dark patch near the middle, with 2 faint dark 'lanes' or rifts, like those in M 13.

PERSEUS.

Here again we enter upon one of the most splendid portions of the Galaxy. Night after night the telescope might be employed in sweeping over its magnificent crowds of stars, among which many beautiful pairs, with the aspect of connection, would be found. This constellation includes the most conspicuous of, at least, the regularly variable stars, β, or Algol (III^h 0^m, N 40° 27′), which changes from 2 to 4 m. in a few seconds less than 2^d 20^h 49^m, the increase and decrease together occupying not more than 7^h, the minimum only 18^m: so that it usually appears 2 m. There are, however, slight irregularities in these times,—probably the slow working of some unknown general law, which may affect all these wonderful bodies.

Double Stars.

ϵ (Σ **471**). III^h 49^m, N 39° 38′: 3·5, 9, 1832: 9°·1: 8″·4: pale white, lilac. [9 very small for this mag. 1849, several times, once with Bishop's 7 in. achr. so my 5½ in. 1863. Yet De 8 of Σ's scale, 1855.]

ζ (Σ **464**). Quadruple. III^h 46^m, N 31° 30′: 3·5, 10, 12, 11, 1832: 206°·6, 198°·1, 185°: 13″·2, 83″, 121″: flushed white, smalt blue, ashy, blue. The attendants seemed to me, 1850, to increase their size with their distance; 10 however might have been overpowered by 3·5. ♅ also appears to

[PERSEUS]

have found but three; can one be var? H, D, and Kn see a minuter 5th star, quite obvious with $9\frac{1}{3}$ in. spec. Kn gives $290^{\circ}\cdot2$: $34''$, 1860: also $90''$ for 12.

η (Σ **307**). $\text{II}^h\ 41^m$, N $55^{\circ}\ 21'$: 5, 8·5: $300^{\circ}\cdot4$: $28''$: reddish yellow, blue. Burnham 5 faint companions.

P II 220, 222 (Σ **331**). $\text{II}^h\ 52^m$, N $51^{\circ}\ 50'$: 6, 8: $85^{\circ}\cdot5$: $12''\cdot5$: silvery white, sapphire blue. Visible to naked eye, forming a triangle with γ and τ.

20 (Σ **318**). $\text{II}^h\ 45^m$, N $37^{\circ}\ 49'$: 6·5, 10: $236^{\circ}\cdot5$: $13''\cdot9$: pale white, sky blue. 'Neat test object,' (Sm) which $3\frac{7}{10}$ in. shewed readily. Closely *f* 16, 5 m.

12. $\text{II}^h\ 34^m$, N $39^{\circ}\ 39'$: 6: yellow, has two pairs near it, in a large field.

58. $\text{IV}^h\ 28^m$, N $41^{\circ}\ 0'$: 5·5: orange, has a pair (Σ **563**) in field; 7·5, 9: $29^{\circ}\cdot8$: $11''\cdot8$: greenish, lilac.

57. $\text{IV}^h\ 24^m$, N $42^{\circ}\ 47'$: 8, 8: $199^{\circ}\cdot8$: $110''$: white, 1833 [not exactly alike in colour, 1852].

H VIII 80. $\text{III}^h\ 40^m$, N $52^{\circ}\ 16'$: 8, 11: 255°: $9''\cdot5$: light yellow, pale violet. (Σ **446**) in cl. so named, Gen. Cat. 775.

(Σ **533**. $\text{IV}^h\ 16^m$, N $34^{\circ}\ 1'$: 6, 7·5: $60^{\circ}\cdot3$: $19''\cdot6$: white.)

(Σ **552**. $\text{IV}^h\ 23^m$, N $39^{\circ}\ 44'$: 6·3, 6·5: $114^{\circ}\cdot4$: $9''$: very white.)

[Σ **425**. $\text{III}^h\ 32^m$, N $33^{\circ}\ 42'$: 7·3, 7·3: $104^{\circ}\cdot6$: $2''\cdot9$: very white. A true 'pair,' a little *p* 40, 6 m.]

[Σ **443**. $\text{III}^h\ 38^m$, N $41^{\circ}\ 5'$: 8·2, 8·8: $44^{\circ}\cdot3$: $9''\cdot1$: white. The second star nearly *s* of ν, about 1° distant.]

[P III 37, 6 m. orange—near α, *s* a little *p*,—has a fine blue companion in a beautiful field.]

(Red Stars. $\text{I}^h\ 54^m$, N $54^{\circ}\ 33'$: 8·5 m.—$\text{II}^h\ 29^m$, N $56^{\circ}\ 28'$:

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9 m.—III^h 36^m, N 53° 28′: 9m. all H.—III^h 32^m, N 47° 19: 8 m. Birmingham.)

Clusters.

512, 521 (H VI 33, 34). II^h 10^m, N 56° 34′. These two gorgeous clusters, described by Sm as 'affording together one of the most brilliant telescopic objects in the heavens,' are visible to the naked eye as a protuberant part of the Galaxy, and so H considered them. They are often called *the sword-hand of Perseus.* With 64 these superb masses were visible together, as well as a bright pair *n*. 5½ in. shewed a red star between them. Sm. mentions a ruby and a garnet in 521. 9⅓ in. spec. shews 5 red stars in all.

584 (M 34). II^h 34^m, N 42° 11.′ Just perceptible to naked eye; a very grand low-power field, one of the finest objects of its class. It contains a little 8 m. pair, 14″ apart.

553 (H 227). II^h 24^m, N 56° 57′. Wide cl. H 13–15 m. A little *f* 512.

658 (H VI 25). III^h 6^m, N 46° 45′. A low power shews a very faint large cloud of minute stars (H 12–15 m.), beautifully bordered by a foreshortened pentagon of larger ones.

385 (M 76). I^h 34^m, N 50° 54′. Pearly-white neb. double. [curious miniature of M 27, and like it, *gaseous*, *p* a little the brighter.]

[820 (H VII 61). IV^h 5^m, N 50° 53′. Bright cl. good low-power object; larger stars in curves.]

[Fine group round a 7 m. orange star, 2° *p* η.]

[Beautiful field, about II^h 12^m, N 54°.]

PISCES.

A dull region, containing some good telescopic objects.

Double Stars.

α (Σ **202**). $1^h\ 55^m$, N $2°\ 8'$: 5, 6: $334°{\cdot}7$: $3''{\cdot}6$, 1834; Kn $325°{\cdot}8$: $3''{\cdot}2$, 1865: pale green, blue, 1834, 1838, 1850; Σ ditto, 1831; D very white, white, 1846; Fletcher both yellow, 1851; De white, ashy white, 1854; P Sm both white, 1856; I found the contrast certain, but 6 troublesome as to colour, usually ruddy or tawny, sometimes bluish; see remark under P XIV 69 Boöt. p. 212. 1855, $3\frac{7}{10}$ in. I noted it pale yellow, brown yellow; 'quite satisfactory;' 1860, $5\frac{1}{2}$ in. pale yellow, tawny or fawn-coloured, 'certain;' 1862, 6 bluish?? no strong contrast; 1871, 9 in. spec. brownish; at first fancied bluish. Both mags. are very variously given. Fletcher, Jacob, and D think this fine object may be binary.

ψ^1 (Σ **88**). $0^h\ 59^m$, N $20°\ 47'$: 5·5, 5·5: $160°{\cdot}4$: $30''$: flushed white, pale white. [Star 12 mag. *s f*, 9 in. spec. 1871.]

65 (Σ **61**). $0^h\ 43^m$, N $27°\ 0'$: 6, 7, 1838: $298°{\cdot}5$: $4''{\cdot}5$: pale yellow. [Very little, if at all, unequal, 1850, *p* possibly the smaller; the same, by independent estimate, 1855; so Walker, 1863; I found *p* larger?? 1862; equal, 9 in. spec. 1871; Σ equal, *p* perhaps a very little the smaller, 1832; D 6, 6, 1839. Sm observes that P had made Sm's 6 his companion star, and therefore must have seen it the lesser.]

35 (Σ **12**). $0^h\ 8^m$, N $8°\ 10'$: 6, 8; $149°{\cdot}5$: $11''{\cdot}9$: white, purplish, 1850; Σ white, 1836.

ζ (Σ **100**). $1^h\ 7^m$, N $6°\ 53'$: 6, 8: $63°{\cdot}8$: $23''$: white, greyish. 6 var. up to 4? Σ and Main c. p. m.

[PISCES]

55 (Σ **46**). $0^h\ 33^m$, N 20° 44′: 6, 9: 193°·7: 5″·9: orange, deep blue, 'rich specimen of opposed hues,' 1833; De yellow, deep red, 'couleurs sûres,' 1856. [9 very small, its colour indistinct, 1848, 1850; 10 m. 9 in. spec. 1871.]

52. $0^h\ 26^m$, N 19° 35′: 6, 14: 311°: 25″: fine yellow, deep blue. [easy, 9 in. spec. 1871.]

P I 123 (Σ **138**). $1^h\ 29^m$, N 6° 59′: 6·5,* 8: 19°·8: 1″·5, 1832; De 28°·7: 1″·6, 1863: creamy white. Binary. Fine test, requiring beautiful weather: elongated, 80; in contact, 144; divided, 250. Between μ and o; but there are several similar stars around: look for a long, narrow trapezium in the finder; it will be the *p* of the two *s* stars: in the telescope a 10 m. star lies near it *s f*.

51 (Σ **36**). $0^h\ 26^m$, N 6° 14′: 6·5, 9: 82°·5: 28″: pearl white, lilac.

100 (Σ **136**). $1^h\ 28^m$, N 11° 54′: 7, 8: 78°·9: 15″·9: white, pale grey. Closely *n p* π.

P I 85, 87. $1^h\ 22^m$, N 7° 17′: 7, 8·5: 98°·7: 68″: pale yellow, bluish.

42 (Σ **27**). $0^h\ 16^m$, N 12° 46′: 7, 13: 341°·5: 35″: topaz, emerald; strong contrast. [13 too small for colour, 9 in. spec. 1871.]

38 (Σ **22**). $0^h\ 11^m$, N 8° 10′: 7·5, 8: 235°·9: 4″·8: light yellow, flushed white. Σ c. p. m. Closely *f* 35, *supra*.

77 (Σ **90**). $0^h\ 59^m$, N 4° 13′: 7·5, 8: 82°·5: 32″: white, pale lilac.

P O 251 (Σ **80**). $0^h\ 53^m$, N 0° 5′: 8, 9: 299°·8; 18″·4, 1832; 305°·1: 18″·8, 1852: pale orange, clear blue. Binary?

* Probably a mistake (Kn, who sees them nearly equal, as did Σ, both 7·3).

[PISCES]

[Σ **155.** 1^h 37^m, N 8° 50′: 7·5, 7·9: 332°·8: 4″·6: white. Beautiful field, a little *n p o.*]

(19. Red Star. XIX^h 14^m, N 27° 1′: 7 m. Buckingham, 1868.)

SAGITTA.

A little asterism, of much greater antiquity than might have been supposed from its size and the smallness of its components.

Double Stars.

ζ (Σ **2585**). XIX^h 43^m, N 18° 49′: 5, 9: 312°·3: 8″·6: silvery white, blue, 1831, 1838; 5 flushed white, 1850; D yellow, 1841, 1848, white, 1843; De yellow, 1856.

ε. XIX^h 31^m, N 16° 10′: 6, 8: 80°·9: 92″: faint yellow, bluish.

θ (Σ **2637**, 49 App. I). Triple. XX^h 4^m, N 20° 32′: 7, 9, 8: 327°·1, 226°·6: 11″·4, 70″: pale topaz, grey, pearly yellow.

[10, 11, two 6 m. stars, form a good object in a rich field.]

[13, 6 m. orange, is the *lucida* of a beautiful group, containing a smaller very red star, and a pretty little 10 m. pair.]

[15, 6 m. commands another fine group. *n* a little *p*, at a few minutes' distance, is P XIX 392, 7 m. beautiful sapphire blue.]

[η, 6 m. yellow, lies in a rich region. A circle around it of 30′ or 40′ radius will include several very pretty little 8 or 9 m. pairs, on different sides of it.]

Cluster.

4520 (M 71). XIX^h 48^m, N 18° 27′. Large and dim, hazy to low powers with $3\frac{7}{10}$ in. yielding a cloud of faint stars (H

[SAGITTA]

11–16 m.) to higher magnifiers; an interesting specimen of the process of nebular resolution. In Galaxy, rather more than 1° *s p* γ. About 1° *s p* M 71 is a beautiful low-power field, containing a pair and a triple group, all about 8 or 9 m.

SAGITTARIUS.

The stars of this constellation have a beautiful effect above the S. horizon, near the place where the Galaxy passes from sight in our latitude; but they are apt to be obscured by haze. The Milky Way is here very rich in a transparent night.

Double Stars.

μ^1. Triple. XVIII^h 6^m, S 21° 5′: 3·5, 9·5, 10: 315°, 114°·5: 40′, 45″: pale yellow, two reddish, 1835 [10 bluish, equal at least to 9·5, 1850, 1855]. H another *comes*, 13 m. 267°: 18″.

54. XIX^h 33^m, S 16° 35′: 5·5, 8: 42°·8: 28″: yellow, pale lilac. Fine field of minute stars.

(21. XVIII^h 18^m, S 20° 37′: 5, 9: est. 287°: 2″: orange, blue. Buckingham.)

[About 1¼° *s* of λ, XVIII^h 20^m, S 25° 29′ is a fine 7 m. triangle, the *s* and *f* stars of which have smaller attendants.]

(Red Star. XIX^h 27^m, S 16° 40′: 7 m. H.)

Clusters and Nebulæ.

4424 (M 22). XVIII^h 28^m, S 24° 0′. Beautiful bright cl. very interesting from the visibility of the components (the largest 10 and 11 m.), which makes it a valuable object for common telescopes, and a clue to the structure of more distant

[SAGITTARIUS]

or difficult nebulæ. H makes all the stars of two sizes, 11 and 15 m. as if 'one shell over another.' Midway between μ and σ.

M 25. XVIII^h 24^m, S 19° 9′. Coarse and brilliant.

4367 (M 21). XVII^h 57^m, S 22° 31′. In a lucid region.

4388 (H VII 30). XVIII^h 5^m, S 21° 36′. Curious large undefined cloud of 10 m. (H 11–13 m.) stars; requiring low power and steady gazing; ½° *s* of μ^1.

4406 (M 28). XVIII^h 17^m, S 24° 56′. Not bright: H 14–16 m. 1° *n p* λ.

4543 (M 75). XIX^h 58^m, S 22° 17′. Bright nucleus with low power. H resolvable.

4510 (H IV 51). XIX^h 37^m, S 14° 28′. Plan. like a star out of focus. Huggins gaseous spectrum. 2° *n* a little *f* 54.

[4361 (M 8). XVII^h 56^m, S 24° 21′. Splendid Galaxy object; visible to naked eye. In a large field we find a bright coarse triple star, followed by a resolvable luminous mass, including two stars, or starry centres, and then by a loose bright cl. enclosed by several stars: a very fine combination. H a set of milky streaks and loops. Se suspects change, and finds the spectrum gaseous.*]

* A little *n p* μ, XVII^h 57^m, S 18° 50′, is a spot referred to by Se as exemplifying in a high degree the marvellous structure which the great achromatic at Rome shews in the Galaxy. The remarks of this accomplished astronomer on the successive layers of stars are very curious: first he finds large stars and lucid clusters; then a layer of smaller stars, certainly below 12 m.: then a nebulous stratum with occasional openings. But what he says startled him, and all to whom he shewed it, was the regular disposition of the larger stars in figures 'si géométriques qu'il est impossible de les croire accidentelles. La plus grande partie sont comme des arcs de spirale; on peut compter jusqu'à 10 ou 12 étoiles de la 9ième à la 10ième grandeur . . . se suivant sur une même courbe comme les grains de chapelet; quelquefois elles forment des rayons qui

SCORPIO.

A fine constellation, little noticed by casual star-gazers, from its low altitude and short continuance above the horizon, with the additional disadvantage of its culminating during the brief summer's night. The student will do well to look out for it, and it will repay an hour or two of extra watching.

Double Stars.

α (Antares). XVI^h 21^m, S 26° 9′. This great star Sm justly terms 'fiery red:' and it is a grand telescopic object. Its tint however, is not uniform: to me the disc appears yellow, with flashes of deep crimson alternating with a less proportion of fine green. This latter mixture has perhaps been subsequently accounted for by the discovery (in 1846,* by Mitchell in America) of a 7 m. green (blue, Kn, P Sm) star near enough to the principal to be usually involved in its flaming rays; and forming an atmospheric rather than an optical test. Warner has seen it with 2¾ in. D, who measured it 275°·7: 3″·7, 1864, noticed a curious proof of its independent, not contrasted green light, when it emerged, in 1856, from behind the dark limb of the Moon before its overpowering neighbour.

semblent diverger d'un centre commun, et ce qui est bien singulier, on voit d'ordinaire que, soit au centre des rayons, soit au commencement de la branche de la courbe, on trouve une étoile plus grande et rouge. Il est impossible de croire que telle distribution soit accidentelle.' He mentions, besides this spot, several instances in Cygnus. What a remarkable parallel to the spiral structure discovered by the E. of Rosse in so many nebulæ! See also Sm's remark on M 35, p. 248 *antea.*

* So generally stated, but Burg had noticed a double emersion from occultation in 1819: and Grant had discovered the *comes* in India, 1844, July 23. (*Monthly Notices*, XXIII. 1.)

[SCORPIO]

β. xvi^h 58^m, S 19° 27′: 2, 5·5: 24°·9: 13″·1: pale or yellowish white, lilac.

ν. xvi^h 4^m, S 19° 7′: 4, 7: 338°·5: 40″: pale yellow, dusky. Jacob subdivides 7 into 7, 8: 1″·75; I have seen it easily with 5½ in. Grover has even just separated it with 2 in. and it could not have escaped H, or indeed Sm in 1831, if as conspicuous then as it is now.

σ. xvi^h 13^m, S 25° 17′: 4, 9·5: 271°·6: 20″: dusky white, plum colour.

ξ, alias, but erroneously,* 51 (ξ) Libræ, (Σ 1998). xv^h 57^m, S 11° 1′: 4·5, 5: 13°·3: 1″·1, 1838; Se 161°: 0″·4, 1866; De 173°·1: 1″·1, 1871: bright white, pale yellow (D both yellowish). Binary, but measures discordant. A third star, 7·5: 74°·2: 7″·2, 1838; De 70°·3: 7″, 1870: grey, may also be moving. A small pair lies *s* a little *f*. [Elong?? 1851. Beautiful field.]

P XVI 236. xvi^h 49^m, S 19° 20′: 6·5, 8: 230°·6: 5″·8: creamy white, greenish. Binary?

31. xvii^h 10^m, S 26° 29′: 6·5, 11: 330°·4: 6″·8: pale white, ash-coloured. Identical with 38 Oph.

P XVI 48, 49. xvi^h 13^m, S 19° 48′: 8, 9: 21°·5: 13″·9: dull white, flushed. Another pair in field, forming a beautiful group. 1° *p* ψ Oph.

(2. xv^h 46^m, S 24° 58′: 6, 10·5: est. 270°: 3″. Burnham.)

(11. xvi^h 0^m, S 12° 24′: 6, 12. Burnham. Kn 258°·2: 3″·75.)

Nebulæ.

4173 (M 80). xvi^h 9^m, S 22° 40′. Like a comet; in a beautiful field, half way between α and β. Ḣ calls it the

* From a mistake of Flamsteed's (D), followed even by Σ.

[SCORPIO]

richest and most condensed mass of stars in the firmament. H 14 m. Nearly central, or more probably between it and us, is a strange var. which, 1860, between May 18 and 21 blazed out to 6·5 or 7 m. and had almost faded by June 10. In field, *f* a little *n*, are two vars. R and S, 9–0 m. in about 648 and 364½ d.

4183 (M 4). xvi^h 16^m, S 26° 12′. Large, rather dim, resolvable, followed by a vacant starless space. 1½° *p* *a*.

SERPENS.

A long, rambling constellation, mixed with Ophiuchus. It contains some fine telescopic objects.

Double Stars.

a. xv^h 38^m, N 6° 48′: 2·5, 15: 1°·5: 50″: pale yellow, fine blue. [15 obvious, 9⅓ in. spec. 1867.]

δ (Σ **1954**). xv^h 29^m, N 10° 58′: 3, 5: 196°·2: 2·8″, 1842; D 191°·2: 3″·2, 1865: bluish white, 1831—1842; De yellow, ashy yellow, 1853—1855; whitish yellow, ashy olive, 1856. Fine specimen of the class of moderately close unequal pairs. Binary.

β (Σ **1970**). xv^h 40^m, N 15° 50′: 3·5, 10: 264°·5: 31″: pale blue; [pale yellow, lilac, 9⅓ in. spec. 1872.]

θ^1, θ^2 (Σ **2417**). xviii^h 50^m, N 4° 2′: 4·5, 5: 103°·9: 22″: pale yellow, golden yellow. Sm says 4·5 has been variously rated, and should be watched for variable light: this would be easy, close to so excellent a standard of comparison; but, to prevent mistakes, it must be borne in mind that θ^1, or 4·5, was *p*, 1834. Σ finds c. p. m. This noble

[SERPENS]

pair lies in a dark space between the two streams of the Galaxy. There is a traditional misrepresentation of the latter in this region; where I have found both streams usually misplaced on globes and maps; *p* being at once too narrow and too far W: the centre of this branch, marked by ℍ VIII 72, is really midway between 72 Taur. Pon. and θ Serp. on either side of it. H has given in his 'Outlines of Astronomy' a very accurate description of the Galaxy, which shews how little the common representation is to be trusted.

ν. XVII^h 14^m, S 12° 43′: 4·5, 9: 31°·3: 51″: pale sea-green, lilac, 1832; silvery, native copper, 1851. [*comes* small, 1850, 1855.]

59 (Σ **2316**). XVIII^h 21^m, N 0° 7′: 5·5, 8: 314°·2: 3″·9: yellow, indigo blue. Brightest of the vicinity.

5 (Σ **1930**). XV^h 13^m, N 2° 0′: 5·5, 10·5: 39° 8: 10″·3: pale yellow, light grey. Very near M 5, p. 260.

49 (Σ **2021**). XVI^h 7^m, N 13° 53′: 7, 7·5: 318°·1: 3″·3, 1839; De 324°·6: 3″·5, 1864: pale white, yellowish. Binary in 600 y?

P XV 220 (Σ **1987**). XV^h 51^m, N 3° 47′: 8, 9: 324°·7: 10″·5: white, grey, 1834; De 8 blue, 'sûre,' 1856. Binary? 1½° *s f* ε.

(6. XV^h 14^m, N 1° 11′: 6, 12: est. 30°: 2″·5. Burnham.)

[Σ **2017**. XVI^h 6^m, N 14° 53′: 7·7, 8·4: 249°·7: 25″: yellow, white. A pretty pair.]

Clusters.

[4410 (ℍ VIII 72). XVIII^h 21^m, N 6° 29′. Very fine, with a 6 m. star in the field: visible to naked eye. Baxendell finds an outlier (T Serp.) var. 10·5 m. to below 14 m. in 340·5 d.

[TAURUS]

7 (Σ **412**). III^h 27^m, N 24° 2′: 6, 6·5: 265°: 0″·7, 1833; Kn 240°·8: 0″·5, 1864: white, pale yellow. [Fine test; elongated, 5½ in. 1861.] A bluish 11 m. star, 61°·9: 22″: makes it triple.

χ (Σ **528**). IV^h 15^m, N 25° 19′: 6, 8: 25°·1: 19″·3: white, pale sky blue or grey.

80 (Σ **554**). IV^h 23^m, N 15° 21′: 6, 8·5: 13°·9: 1″·6, 1832; 15°·2: 1″·8, 1843: yellow, dusky. [*Comes* not seen, 3$\frac{7}{10}$ in. 1851.] Measures discordant, but Σ c. p. m. In Hyades, about 1½° *s p a*.

φ. IV^h 12^m, N 27° 2′: 6, 8·5: 241°·8: 56″: pale red, blue.

111. V^h 17^m, N 17° 16′: 6, 8·5: 271°·2: 63″: white, lilac, 1832, 1857 [yellow, lilac, 1851].

30 (Σ **452**). III^h 41^m, N 10° 45′: 6, 10: 58°·5: 9″: pale emerald, purple, 1839; colour less decided? 1858.

118 (Σ **716**). V^h 21^m, N 25° 3′: 7, 7·5: 195°·9: 5″: white, bluish. Between tips of horns, nearer *n*.

P IV 257. Triple. IV^h 52^m, N 14° 21′: 7, 8, 10: 303°·8, 88°·3: 39″, 70″: white, cerulean blue, purple. *n f* o^1 and o^2 Orion.

62 (Σ **534**). IV^h 16^m, N 24° 0′: 7, 8·5: 290°: 29″: white, pale purple. In a fine field.

P V 37 (Σ **680**). V^h 12^m, N 20° 0′: 7, 11: 204°·1: 9″: deep yellow, bluish. The last of a curious series of 6 stars nearly *f* each other.

P III 213 (Σ **479**). Triple. III^h 53^m, N 22° 50′: 7·5, 8, 12, 1835: 128°·1, 240°: 7″·2, 60″: white, grey, blue. [8 more like 9; 12 like 10, 1855.] 12 is probably var. South missed it, 1823. Σ rated it differently in different years. 3° *f* Pleiades, a little *s*.

[TAURUS]

P V 20 (Σ **670**). $v^h\ 9^m$, N 18° 18′: 8, 8·5: 168°·5: 2″·1: bluish.

[Σ **548**. $iv^h\ 21^m$, N 30° 4′: 6, 8: 35°·9: 14″·2: yellowish, bluish.]

(Σ **495**. $iv^h\ 0^m$, N 14° 49′: 6, 8·8: 216°·1: 3″·6: yellowish, bluish.)

[Σ **401**. $iii^h\ 24^m$, N 27° 8′: 6·5, 7: 270°: 11″·1: white. A wide pair 7·5 m. 10′ *n p* makes a fine group.]

[Σ **730**. $v^h\ 25^m$, N 16° 58′: 6·5, 7: 141°·8: 9″·8: very white; 7, 7·3: yellowish, bluish, 9 in. spec. 1872.]

[Σ **559**. $iv^h\ 26^m$, N 17° 44′: 7, 7: 278°·7: 3″: very white. Between *a* and *ε*, rather nearer *a*, *f* the line joining them.]

(Σ **749**. $v^h\ 29^m$, N 26° 51′: 7·1, 7·2: 23°·4: 0″·67, 1829; Romberg, 186°·9: 0″·8, 1864: very white. Severe test. Divided by Buffham with 6½ in. 'With' mirror.)

[Σ **742**. $v^h\ 29^m$, N 21° 55′: 7·2, 7·8: 246°·2: 3″·3: yellowish, white. Moving?]

[σ^1, σ^2 (Σ 11 App. I). $iv^h\ 32^m$, N 15° 32′: 5·2, 5·7: very white, look like a connected system: so do κ^1, κ^2 (Σ 9 App. I). $iv^h\ 18^m$, N 22° 0′: 5, 6: between which, with 5½ in. I saw a very pretty minute pair.]

(Red Star. $iii^h\ 35^m$, N 14° 21′: 9 m. H.)

Nebula.

1157 (M 1). $v^h\ 27^m$, N 21° 56′. Oblong; pale; 1° *n p* ζ, on *s* horn. The Crab Nebula of E. of Rosse, who resolved it and brought out its curious fringes and appendages. Se has obtained the same result. Its accidental discovery by M, while following a comet in 1758, led to the formation of the earliest

catalogue of nebulæ. Birmingham finds a pretty little pair 2^m *f*.

[768. III^h 38^m, N 23° 20′. The Nebula in the Pleiades, discovered by Tempel, 1859, Oct. 19: a faint extended somewhat triangular haze, involving Merope, the bright star *s p* the *lucida*, at its *n* extremity. *Strongly suspected var.* but evidence conflicting. Has been seen with less than 2 in. Found readily by me, 1863, Oct. 6, with 5½ in.—very feeble, 1865, Sept. 25;—a mere glow, when star out of field, 9 in. spec. 1872, Mar. 4.

TAURUS PONIATOWSKII (OR *PONIATOVII*).

A little asterism in a very rich and beautiful part of the Galaxy.

Double Stars.

P XVII 362 (Σ **2276**). XVIII^h 0^m, N 12° 0′: 8, 8·5: 257°·9: 6″·9: straw yellow, sapphire blue, 1831, 1838; De white, green, 1855–6. [mags. underrated, 1850? Σ 6, 7, 1830.]

[About XVII^h 55^m, N 7° 45′ is a wide 8, 8·5 m. pair, 1¼° *s p* 71, 6 m.]

(Σ **2404**. XVIII^h 45^m, N 10° 50′: 6, 7·5: 183°·1: 3″·5: yellow, blue; 'colours remarkable.')

(Σ **2375**. XVIII^h 39^m, N 5° 22′: 6·2, 6·6: 108°·1: 2″·2: white.)

TRIANGULUM.

An ancient constellation, including several good objects.

Double Stars.

ι (Σ **227**). II^h 5^m, N 29° 42′: 5·5, 7: 78°·8: 3″·5: topaz yellow, green: 'exquisite,' Sm.

[TRIANGULUM]

(P II 89 (Σ **269**). $11^h\ 21^m$, N 29° 17′: 6·5, 10: 342°·1: 2″·3: yellow, grey. This star is wrongly called P II 93 in the Bedford Catalogue, through a mistake of Σ's. Sm's mag. of the larger star is also too high. Σ gives 7·5.)

P II 160 (Σ **300**). $11^h\ 37^m$, N 28° 55′: 8, 8·5: 297°·8: 2″·9: cream-white, 1831 [white, yellowish or ruddy, 1850].

P II 38, 39 (Σ **239**). $11^h\ 10^m$, N 28° 9′: 8·5, 9: 209°·1: 14″·1: silvery white, 1834. [Yellowish, greyish or bluish grey, 1849, 1852, with more than ½ m. diff. Closely *p* 10, 6 m.]

[Σ **197**. $1^h\ 53^m$, N 34° 40′: 7·3, 8·3: 233°·6: 18″·3, 1833; De 21″·7, 1864: white, ashy. A pretty pair, 2° *n p* β.]

[28 (Σ **232**). $11^h\ 7^m$, N 29° 47′: 7·5, 7·5: 245°·6: 6″·6: very white. Closely *f* ι.]

Nebula.

352 (M 33). $1^h\ 27^m$, N 30° 1′. Very large, faint, ill-defined; visible from its great size (H nearly ½° *n* and *s*) in finder, a very curious object, only fit for low powers, being actually imperceptible, from want of contrast, with my 144. Resolved by H into stars 'the smallest points imaginable.' E. of Rosse, who only saw it full of knots, found the same spiral arrangement which prevails so wonderfully in many nebulæ: two similar curves, like an S, cross in the centre.

URSA MAJOR.

This familiar constellation offers a large field to the persevering observer. It must be borne in mind that it extends far beyond the region occupied by 'the seven stars;' and from the unmarked character of some parts of it, several telescopic objects will require care in their identification. It seems dif-

ficult to ascertain whence this Bear and his companion derived their preposterous length of tail. Dr. Mather, in 1712, tells a curious story, that though the Red Indians did not divide the stars into constellations, they called the stars of Ursa Major, *Paukunawaw*, that is, the Bear, long before they had any communication with Europeans.*

Double Stars.

α. $\mathrm{x}^{\mathrm{h}}\ 56^{\mathrm{m}}$, N 62° 27′: 1·5, 8: 203°·8: 381″: yellow, 1832 [8 violet, 1850]. H 1·5 var? Huggins finds that it is approaching us at 46 to 60 miles per second, while *β*, *γ*, *δ*, *ε*, *ζ* are receding at 17 to 21 miles.

ζ (Σ **1744**). $\mathrm{xiii}^{\mathrm{h}}\ 19^{\mathrm{m}}$, N 55° 36′: 3, 5: 147°·4: 14″·4: brilliant white, pale emerald. This fine pair, which is said to have been discovered by Riccioli, and again noticed 1700, Sept. 7, by Gottfried Kirch and his scientific wife Maria Margareta, and which may possibly be travelling together through space, forms a noble group with Alcor, 5 m.† 11½′ distant (the 'rider upon the horse'), and another smaller star, visible to some persons without a telescope. *ζ*, or Mizar, and Alcor, form a pair to the naked eye: and thus become an excellent object for a beginner, as the telescopic increase of brightness and distance admits of direct comparison; but the inversion of the astronomical eye-piece must be borne in mind, or the identity will be perplexing.

* I am informed, however, on the highest authority that in the language of the Cree Indians this word signifies 'ye are alone; isolated.' The word for *bear* is *muskwa*.

† Brightening? Kn. It certainly is no longer the severe naked-eye test, which it used to be even in the Arabian sky.

[URSA MAJOR]

ι. VIII^h 50^m, N 48° 33′: 3·5, 13: 348°: 12″: topaz yellow, purple. H thought 13 might shine by reflected light. Buffham found it very dull for its size. [not seen.]

ξ (Σ **1523**). XI^h 11^m, N 32° 16′: 4, 5·5: 207°·5: 1″·8, 1830; 123°·5: 2″·9, 1851; Se 86°·6: 2″·2, 1866; Kn 29°·7: 1″·1, 1872: subdued white, greyish white. Period about 61 y.—Ball 59·88 y. the earliest calculated binary: but the errors are large, though it has been watched through more than one revolution.

23 (Σ **1351**). IX^h 21^m, N 63° 38′: 4, 9·5: 271°·8: 23″: pale white, grey.

ν (Σ **1524**). XI^h 12^m, N 33° 45′: 4, 12: 147°·2: 7″·8: orange, cerulean blue. [*comes* missed, $3\frac{7}{10}$ in.)

σ^2 (Σ **1306**). VIII^h 59^m, N 67° 40′: 5·5, 9·5: 262°·4: 5″, 1835; De 252°·7: 3″·2, 1865: flushed white, sapphire blue. Binary: therefore smaller stars are not always more distant from us. *Comes* very difficult, $3\frac{7}{10}$ in. 80; plain, 144.

P XI 111 (Σ **1555**). XI^h 29^m, N 28° 30′: 6, 7: 340°·1: 1″·4: pale blue [elong. $3\frac{7}{10}$ in. 250]. Sm says, 'it is situated in a very vacant space to the eye . . . but to the powerful reflectors now in use, is in a very ocean of nebulæ.' [13 m. 145°: 17″: missed, $3\frac{7}{10}$ in.]

P XIII 156 (Σ **1770**). XIII^h 33^m, N 51° 26′: 6, 8: 119°·9: 1″·9: topaz yellow, livid. 2° *n p* η, on a line pointing to ϵ; the further from η of two adjacent stars.

57 (Σ **1543**). XI^h 22^m, N 40° 6′: 6, 9: 9°·9: 5″·9: lucid white, violet; D yellow, vivid violet. 9 moving; var.?

65 (Σ **1579**, 20 App. I). Triple. XI^h 48^m, N 47° 12′: 7, 9·5, 7: 35°·8, 115°: 3″·8, 63″: bright white, pale purple, white. Sm suspects two latter var. and all connected. 2° *s f* χ.

[URSA MAJOR]

P XIII 277 (Σ **1795**). XIII^h 54^m, N 53° 44′: 7·5, 12: 4°·9: 6″·8: bright white, pale blue. 12 singularly distinct for its mag., as Sm observes. I saw it well. In a string of stars reaching from ζ towards the coarse group in the hand of Boötes.

P X 58 (Σ **1428**). X^h 18^m, N 53° 17′: 8, 8·5; 85°: 3″·6: white.

21 (Σ **1346**). IX^h 16^m, N 54° 34′: 8, 9: 310°·9: 6″·3: silvery white, violet.

[Σ **1561**. XI^h 32^m, N 45° 50′: 5·9, 8: 266°: 10″·4: yellowish white, ashy [prettily grouped.]

(Σ **1415**. X^h 7^m, N 71° 43′: 6·1, 7: 167°·1: 16″·4: very white.)

(Pair. XII^h 50^m, N 54° 48′: 6, 9: est. 285°: 4″. Birmingham.)

(Σ **1559**. XI^h 32^m, N 65° 4′: 6·2, 7·8: 2″·1: white, greyish.)

(Var. 83. XIII^h 36^m, N 55° 17′: 5 m. was seen by Birmingham, 1868, Aug. 6,=δ. It subsequently faded.)

Nebulæ.

1949, 1950 (M 81, 82). IX^h 45^m, N 69° 44′. Two neb^a ½° apart: 81 bright, with vivid nucleus, finely grouped with small stars, two of which are projected upon the haze, to which H gives nearly 15′ of length, Two little pairs *s p* make the field very interesting. The nearer is Σ **1387**. 9·5, 9·5: 269°·6: 8″·9—the further is Σ **1386**. 8·2, 8·2: 296°: 2″, 1832; Kn 1″·6, 1864; Gill 291°·4: 2″·4, 1870. 82 a curious narrow curved ray. Huggins finds both spectra continuous, but deficient at the red end.

2841 (H V 43). XII^h 13^m, N 48° 1′. Bright, oval, denser in centre, Continuous spectrum.

2343 (M 97). XI^h 7^m, N 55° 43′. Large pale plan. neb. a very curious object. H gives it a diameter of 2′ 40″, which at the distance of 61 Cygni only, would fill a space equal to seven times the orbit of Neptune. He saw its light perfectly equable, with only a softened edge; but E. of Rosse found two large perforations and a resolvable spiral arrangement—a striking instance of the advantage of a larger aperture. Of two stars, one in each opening, one only seen since 1850. Huggins gaseous spectrum. 2° *s f* β.

2318 (H V 46). XI^h 4^m, N 56° 22′. Elongated; small star in centre. 1° *s f* β.

1823 (H I 205). IX^h 14^m, N 51° 33′. Dull, in a fine field with 37, 6 m. 1½° *s p* θ. There are several pretty little pairs in the neighbourhood.

URSA MINOR.

This constellation is distinguished by a still more inappropriate length of tail than its larger neighbour, by which, as Sm observes, it is swung round every 24 hours: at its extremity stands the most valuable star in the heavens, Polaris, the first of the following list, 1° 23′ from the polar point, which, from the precession of the equinoxes, it will approach as near as 26′ 30″ (its nearest), A.D. 2095.

Double Stars.

α (Σ 93). I^h 12^m, N 88° 37′: 2·5, 9·5: 210°·1: 18″·6: yellow, dull white, 1830, 1838, 1849; D 9·5 bluish: and so

[URSA MINOR]

I see it. A common test, but only suited for small apertures, being easily seen with anything much exceeding 2 in. D has proposed it as a general standard, finding that 2 in. and a power of 80 will shew it if the eye and telescope are good; he has seen it with $1\frac{6}{10}$ in. Dawson has glimpsed it with 1 in. Buffham sees it with $1\frac{1}{2}$ in. refl. In the Dorpat achr. it has been perceived by day.

π^1 (Σ **1972**). XV^h 37^m, N 80° 53′: Σ 6·1, 7: 83°: 30″: yellowish (Sm yellow, blue). Easily found *n p* ζ.

(π^2 (Σ **1989**). XV^h 47^m, N 80° 23′: 7·1, 8·1: 24°·1: 0″·7: very white.)

VIRGO.

A constellation especially remarkable, for those possessed of adequate optical means, on account of the wonderful *nebulous region*, in which a far greater number of these extraordinary bodies are accumulated, than in any other equal area of the heavens; H having detected within its boundaries no less than 323. Few of them, however, are individually interesting; it is the mysterious thronging together of these objects, whatever may be their nature, that opens such a field for curiosity. They are in general so much alike, that I have only adduced a few as specimens. They are profusely scattered over this quarter of the sky; but the region more especially referred to is pretty well defined to the naked eye by the stars ϵ, δ, γ, η, and β Virg. and β Leon.

Double Stars.

γ (Σ **1670**). XII^h 35^m, S 0° 44′: 4, 4: (H 7″·5: 1790) 77°·9: 1″·6, 1831; 0″, 1836; 191°·6: 1″·9, 1843; 169°·9:

[VIRGO]

3″·8, 1858; D 163°·6: 4″·4, 1867; Kn 159°·8: 4″·5, 1871: silvery white, pale yellow; white the brighter, but colours not always equally intense. Σ thought them alternately var. in brightness, with a possible period of at least several years. Humboldt suggests slow axial rotation in each. Fletcher white, yellow, colours fixed, mags. alternately var. 4, 4·5. Period uncertain, owing to some anomalies; but under 200 y. Adams thinks 174 y. most probable. This wonderful pair has been widening ever since they closed up out of all telescopic reach in 1836 (except at Dorpat, where 1000 still shewed elongation), and a very moderate instrument will now suffice for them.

θ (Σ **1724**). Triple. XIII^h 3^m, S 4° 51′: 4·5, 9, 10: 345°·2, 295°: 7″·1, 65″: pale white, violet, dusky. H and South called 9 a very severe test for a 5 f. telescope, 1824. Σ gave it *his* 9, 1830.

φ (Σ **1846**). XIV^h 22^m, S 1° 39′: 5, 13: 115°: 5″: pale yellow, fine blue [*comes* not seen, 1854].

84 (Σ **1777**). XIII^h 37^m, N 4° 12′: 6, 9: 233°·4: 3″·5: yellowish, smalt blue [difficult, $3\frac{7}{10}$ in.]. Σ c. p. m.

17 (Σ **1636**). XII^h 16^m, N 6° 2′: 6, 9: 336°·2: 19″·8: light rose tint, dusky red. Σ c. p. m.

P XII 196. XII^h 45^m, S 9° 38′: 6·5, 9·5: 307°·9: 33″: topaz yellow, lucid purple. Closely *s p* ψ.

54. XIII^h 7^m, S 18° 8′: 7, 7·5: 33°·5: 5″·7: white, 1839 [pale yellow? pale blue? 1852].

P XIII 238 (Σ **1788**). XIII^h 48^m, S 7° 25′: 7, 8·5: 55°, 1834; De 67°·7, 1864: 2″·5: white. [clearly divided, 80.]

P XI 126 (Σ **1560**). XI^h 32^m, S 1° 43′: 7, 12: 280°·9: 5″: pale orange, reddish. [12 glimpsed? $3\frac{7}{10}$ in.]

[VIRGO]

P XII 32, 33 (Σ **1627**). $\text{XII}^h\ 11^m$, S 3° 14′: 7·5, 7·5, 1836; Σ 5·9, 6·4, 1830: 198°·6: 21″: silvery white. 3° *s* from *η*, a little *p*.

81 (Σ **1763**). $\text{XIII}^h\ 31^m$, S 7° 13′: 7·5, 8: 39°·8: 2″·8: bright white, yellowish. Binary?

P XIII 25. $\text{XIII}^h\ 8^m$, S 10° 40′: 7·5, 8·5: 62°·8: 42″: bluish. 2½° *p α*.

P XII 221 (Σ **1689**). $\text{XII}^h\ 49^m$, N 12° 12′: 7·5, 9: 197°·9: 29″: pale white, sky-blue. 2° *p ε*, a little *n*.

P XIII 127 (Σ **1757**). $\text{XIII}^h\ 28^m$, N 0° 21′: 8, 9: 24°·1: 1″·5, 1832; De 63°: 2″·1, 1869: pale white, yellowish. [elong? 1851.] Period about 240 y? Closely *n p ζ*.

P XIII 171 (Σ **1775**). $\text{XIII}^h\ 37^m$, S 3° 37′: 8, 10·5, 1830: 336°·3: 30″: light orange, pale lilac. [10·5 seen much out of focus with strong moon, 1852.]

[Σ **1669**. $\text{XII}^h\ 35^m$, S 12° 18′: 6·5, 6·5: 298°·9: 5″·4: yellowish white. [very beautiful; a small star *s p*.]

[About $\text{XII}^h\ 24^m$, N 2° 30′ is a fine 8, 8·5 m. pair.]

(Var. $\text{XIII}^h\ 28^m$, S 12° 32′: upwards of 5 m. to 8 m? discovered by Schmidt, 1866: about 2° *s* of *α*, 10^m *f*.)

Nebulæ.

3132 (H I 43). $\text{XII}^h\ 33^m$, S 10° 54′. Elongated: beautiful low-power field. Very fine and singular 7 m. group *n p*.

3182 (M 60). $\text{XII}^h\ 37^m$, N 12° 16′. In field with two others, M 59, *p*, fainter, and H 1402, a minute object, with my 64 like a star, hazy with 80; lying between two small stars.

3900 (H I 70). $\text{XIV}^h\ 23^m$, S 5° 23′. Close to an 8 m. star, and prettily grouped with smaller ones. H resolves it into 19 m. stars. 'So that here,' as Sm says, 'we find another universe in the plenitude of space!'

[VIRGO]

3049 (M 88). XII^h 25^m, N 15° 8′. Elongated and dull. The nebulous district in which it lies is very wonderful; 6 or 7 were swept over with 64, some of them tolerably conspicuous; occasionally two in the same field; among them were probably M 87, 89, 90, 91.

3021 (M 49). XII^h 23^m, N 8° 43′. Inconsiderable, but beautifully situated between two 6 m. stars. Bright open pair *s*.

3274, 3278 (H II 74, 75). XII^h 46^m, N 11° 56′. Two very faint objects in one field; *n p* (3274) the larger and brighter: 3278 is beautifully grouped with 3 stars. Easily found a little *p* P XII 221, which again is near ε.

[2838. M 99. XII^h 12^m, N 15° 15′. E. of Rosse spiral, a wonderful object; Key decidedly resolvable, 18 in. spec. 1° *s f* 6 Comæ, 5 m. the next considerable star *f* β Leonis, at nearly 7°.—Darby.]

VULPECULA.

A little modern asterism, in which its former, Hevel, perceived a new star in 1672, visible for only two years, and not since identified. According to Chacornac, who has recorded many such changes, they are more frequent, even in modern times, than has till of late been suspected; the improvement of catalogues enabling us to discriminate between the 'mistaken entries' of the earlier observers, and real alterations.

Double Stars.

P XIX 320, 321 (Σ 48 App. I). XIX^h 48^m, N 20° 0′: 7, 7: 147°·6: 43″: white. Another pair *p*, followed by a minute star, 5½ in. makes up a pretty group.

[VULPECULA]

P XIX 415 (Σ **2631**). xx^h 2^m, N 20° 44′ : 8, 10 : 340°·5 : 4″·5 : pale white [reddish, 1864], sky-blue. Se moving? 1° *p* θ Sag.

[Σ **2769**. xxi^h 5^m, N 21° 56′ : 6·5, 7·5 : 300°·8 : 17″·8 : white [7·5 bluish, 9 in. spec. 1871.]

(1 (Σ **2445**). xviii^h 59^m, N 23° 8′ : 6·3, 8 : 263°·3 : 12″·2 : very white, ashy.—In Anser.)

Nebula.

Some of my readers may perhaps feel that I have allotted an undue proportion of space to minute and inconspicuous objects. It may be so. I may have erred in supposing that others might receive as much pleasure as myself from their contemplation: yet many comprised in my original scheme have been passed by, as well as a great mass of remarks on the beauty or singularity of those which have been selected. But, should I have failed in communicating to others a portion of my own interest as to some parts of this list, it will be closed with a nebula which I think will not be found disappointing.

4532 (M 27). xix^h 54^m, N 22° 22′. The 'Dumb Bell' Nebula, just visible with a 1¼ in. finder. In a rich field we find two oval hazy masses in contact, of which *p* seems to me the brighter, as it did to H. His reflector failed to resolve it, but shewed the dark notches (which, as Darby remarks, are usually represented too deep) filled in and made protuberant by faint luminosity, converting the whole figure into an ellipse. The Earl of Rosse's 3 f. speculum was thought to reach its starry components : his 6 f. surrounds it with an external ring having a neck like a retort. Bond's achrom. also seemed

to resolve it, but there the form shewn in small instruments is lost. The minute stars in it, of which I picked out two or three with $5\frac{1}{2}$ in. achr. and 8 in. silvered glass, are admirable tests for superior telescopes. They seem however to be merely part of the host of the Galaxy; for Huggins finds there, by simultaneous comparison, nothing but luminous gas—possibly nitrogen! And here the magnificent apostrophe of Kepler, which closes his speculations on the habitability of our own Sun, may well express our feelings, and form at the same time a most appropriate conclusion to the varied scenes which have passed in review since we commenced these pages:—

'Abrumpo consultò et somnum et speculationem vastissimam: tantum illud exclamans cum Psalte Rege:

'Magnus Dominus noster, et magna virtus ejus, et sapientiæ ejus non est numerus: laudate eum cœli, laudate eum Sol, Luna, et Planetæ, quocunque sensu ad percipiendum, quâcunque linguâ ad eloquendum Creatorem vestrum utamini: laudate eum harmoniæ cælestes, laudate eum vos harmoniarum detectarum arbitri: lauda et tu anima mea Dominum Creatorem tuum, quamdiu fuero: namque ex ipso et per ipsum et in ipso sunt omnia, *καὶ τὰ αἰσθητὰ καὶ τὰ νοερά*; tam ea quæ ignoramus penitus, quam ea quæ scimus, minima illorum pars; quia adhuc plus ultrà est. Ipsi laus, honor, et gloria in sæcula sæculorum. AMEN.'

APPENDIX I.

ADDITIONS AND CORRECTIONS.

The Telescope.—For cleaning lenses, a roll of dry blotting-paper, having its end scraped with a knife, is said to be superior to wash-leather ('English Mechanic,' Apr. 19, 1872). I have found this material rolled to a point, and aided by the breath, answer perfectly on small surfaces of glass.—Tarnished specula, formed of copper and tin only, may be restored by spirits of hartshorn applied with a soft old sponge: clean water being used afterwards, and sponged away. On some old alloys, a crystallized surface may thus be induced, but it may be removed by sulphuric ether and a soft linen cloth. Ammonia may also be used to clean brasswork (Ibid. Dec. 22, 1871). The same very useful publication contains (Oct. 18, 1872) a method of silvering glass specula, said to be of great excellence.—A very ingenious, effective, and cheap equatorial mounting for Newtonian reflectors has been invented by the Rev. E. L. Berthon.

The Sun.—Huggins remarks that there are commonly several nuclei, most frequently 3, in one umbra.—I have failed in recovering my authority for the umbra of 140,000 miles (p. 25); but it seems so disproportionately large that error may be suspected; or 'penumbra' may be intended (see p. 23).—A decided instance of rotation in a spot observed by Elvins, in Sept., and Knobel, in Nov. 1867, is recorded in 'Astron. Register,' Nos. 66, 68.—Wolf's corrected period of *maxima* is 11·1 y.; time of increase, 3·7 y.; decrease, 7·4 y.; epoch of *max.* 1860·2; *min.* 1867·2; with which De La Rue, Stewart, and Loewy very nearly agree. The latter now trace the influence of Venus and Mercury alone on the spots, which seem to be diminished by the presence of these planets.—Angström and Thalèn give 16 elements in the Sun.—The idea of the corporeal nature of the spots is supported by Weiss (Mar. 12, 1864) and Haag (Apr. 13, 15, 16, 1869), who observed what they considered a passage of one over another (Schellen's 'Spectrum Analysis,'

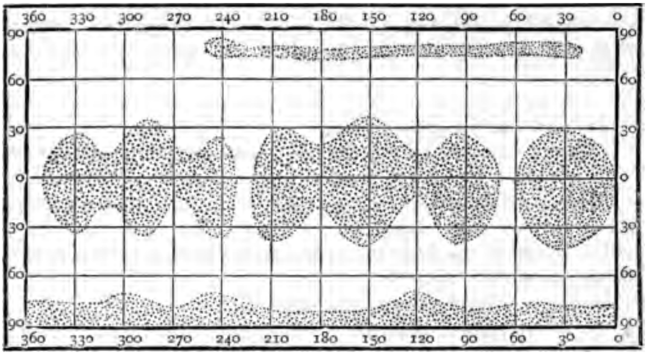
273).—The rotation of the Sun has been given by Carrington at 25·38 d.; by Spörer, 25·23 d. Inclination of axis, Carrington, 7° 15′; Spörer, 6° 57′.—Canon Stark, of Augsburg, is said by Hind to have observed, as well as Pastorff, the transit of the comet in 1819. The same authority has fixed Wray's observation (p. 42) at Whitby.

Venus.—Much attention has of late been paid to this planet, especially since the silvered reflector has been found peculiarly capable of defining it: and the following additional details, many of them due to the Observing Astronomical Society, are of some value, referring in part to phænomena which so eminent an authority as Dawes considered questionable.—This planet alone may undoubtedly be followed through every part of its orbit, when not too close to the solar limb. Near inferior conjunction, the extension of the light beyond a semicircle has been witnessed by Noble and Andrews. The indented terminator, said to be figured (with a spot) at an early epoch by Fontana, has been recorded by Key, Browning, Ormesher, Buffham, and Langdon (who has also seen many spots). When very thin, Buckingham has found it not merely irregular but interrupted at 3 points: Lyman, contracted in 2 places. One or both cusps occasionally blunted, Buffham, Ormesher, Browning, Petty, Noble, Holden (who has seen a bright speck cut off at N. horn when sharper than S.), Langdon (who noticed a sharp bending-in of N. cusp), and an observer signing himself T. P. (who found S. horn at times nearly cut off, and disc often varied by dark and bright spots). Huggins has repeatedly for years noticed a round bright spot, and, as well as Browning, has seen the surface pitted with markings like craterlets.' With describes it (Apr. 6, 1868) as marbled or veined all over, and on the same occasion, using a 12¼ in. unsilvered mirror, perceived a small bright projection on the circular limb,* about 40° from S. cusp; this was confirmed by Key, at about 36°, April 12 and subsequent days, with granulations towards a terminator more deeply serrated than that of the Moon: Mar. 15, Browning had seen a bright patch of some extent 80° from that cusp, so luminous as to show projection like the snow on Mars. Browning and T. P. have very frequently traced the dark limb, and the phosphorescence was seen in the day-time by Langdon and several others a little before inferior conjunction, Feb. 5, 1870. Key thinks this strange phænomenon may be due to auroral or zodiacal light.

A copy of Bianchini's diagram of the spots is given here, as it may

* Compare Schröter and Harding on *Mercury*, p. 44.

materially assist the student in identification; especially if transferred, as it readily may be, to a small globe.



The Moon.—The following additional objects have received names:—491, *Carrington*; 492, *Livingstone*; 493, *Stanley*; 494, *Baker*. The name *Kirch* (130), originally given by Schr. to a mountain, and transferred by B. & M. to a neighbouring crater, has been restored by Birt, the crater being designated 428, *Rumker*.—M. thinks that clefts may still be in process of formation.—Birt says the white spot W. of *Picard* is now much smaller than in 1859–1863, or even later.—He has seen the *M. Serenitatis* very indistinct, scarcely a crater being detected upon it, while the region E. of it was clear and well defined (see p. 73, note). From 133 estimates in 2 years the floor of *Plato* is shewn to darken with increasing illumination.—G.'s 'Astron. Jahrbuch,' 1842, contains an engraving of many remarkable formations, not however referred to in the text, and possibly bound up wrong, from which it appears that the dissimilarity of *Messier* and *Messier A* had not escaped that acute observer. Some of his measures of lunar heights which have been preserved agree remarkably well with those of B. & M.—For German scholars, where expense is an object, M.'s own abridgement of 'Der Mond' (p. 72), entitled 'Kurzgefasste Beschreibung des Mondes,' Berlin, 1839, may be substituted for it.

Jupiter.—Barneby described the equatorial belts as rosy, when the satellites were all invisible, Aug. 21, 1867; Browning saw no strong colour in that region, Dec. 1867; I found it barely noticeable with $8\frac{1}{2}$ in. silvered glass, Nov. 7, 1872.—Gledhill saw the minute round bright

spots (p. 140) Oct. 10, 1870.—Barneby and two others saw the double spot on III., Aug. 21, 1867, of a ginger colour (p. 152).

Comets. Birmingham observed that of Biela illuminated by a star over which it passed, Aug. 23, 1868; and he and Tempel saw Comet II. 1871, as if sprinkled with star-like points.

Antinous. η. Var. 3·6—4·4 mag.

Aquarius. Double, 13′ *s* of 60, which is about $1\frac{1}{2}°$ *s* of η, XXII^h 29^m, S 0° 44′: est. 8·5, 9·5: 210°: 2″, with 13 m. *comes sp.* Burnham.

Aquila. Triple, closely *f* ε, XVIII^h 54^m, N 14° 54′: est. 9·5, 10·5, 10: 260°: 110°: 6″, 14″. Ward.

The colour of the Red Star, p. 204, was remarked by Bessel, 1823. Brightness slightly var. Kn.

Boötes. ε. Binary character uncertain. D.

ι. 8 deep purple; 1848. D.

44. Both sometimes white, sometimes pale yellow. D.

39. Both more usually pale yellow. D.

Σ 1884. White, brownish; 1848. D.

Red Star. XIV^h 18^m, N 26° 21′: 7·5 m. H.

Cancer. ζ. Period of 3rd star probably 600 or 700y. D.

Σ 1177. Pale green, pale yellow; 1854. D.

ω^1. VII^h 53^m, N 25° 45′: 6, 11·5: est. 40°: 2″: golden, greyish blue. Buckingham.

Canis Minor. P VII 170. A most minute star a little *s p*. Hunt, 4in. achr. 1862.

Cassiopea. Quintuple. 0^h 45^m, N 55° 55′ (12^m *f* α): est. 7·75, 11, 8·5, 10, 15: 90°, 135°, 200°, 360°: 1″·5, 4″, 10″, 15″. Burnham.

Cepheus. The *Garnet* * is not μ of A, or B.A.C., the place of which is XXI^h 50^m 51^s.

Corona. ζ. 6 sometimes purplish. D.

η. Both white or yellowish. D. *Comes* glimpsed with 4in. achr. Hunt.

σ. Pale yellow, greenish. D.

Cygnus. δ. 9 blue. D.

[OΣ 389. XIX^h 47^m, N 30° 49′: Dc 7, 9: 183°·2: 12″·5.]

[♅ 640 (H.'s Synopt. Cat. of ♅'s stars). XIX^h 41^m, N 32° 46′ (4^m *p* χ^2, $\frac{3}{4}°$ *s* of χ^1): est. 7, 9·5 (A 6·5, 9): *s p*: 30″? yellow, blue or lilac. Very pretty.]

[Double. ± XX^h 9^m, N 41° 35′: est. 7·5, 10: 40°: 10″.]

[Double. ± xx^h 42^m, N 42° 3′: est. 8, 10: 110°: 10″.]

[χ^2 suspected of losing in colour as it gains in light; 1872.]

Gemini. Ḫ 264 (p. 247). So numbered in H.'s Synopt. Cat. M.R.A.S. xxxv.

R. Var. 7·3—11 mag. in 370d. Blue, yellow, red by turns. Hind; Pogson.

Hercules. 100. Sm gives 2 minute *comites sf*, *nf*, seen by Hunt.

Lynx. Σ 1187. VIII^h 1^m, N 32° 36′: 8, 7·5: 71°: 1″·6, 1829; De 56°·3: 1″·8, 1863: white. Binary [not examined.]

Monoceros. 11. 6·5 certainly orange; 1862. Hunt.

Perseus. ζ. Hunt mags. as Webb. 1861.

Double. 11^m *f* ε, 12′ *n*: est. 2″·5. Burnham.

Pisces. Red * (p. 285) is wrongly placed here.

The following Table of some of the Elements of the Planets (from 'Lockyer's Elementary Lessons in Astronomy') may be found of use.

Symbol.	Mean distance from Sun in miles.	Revolution in days (approximate).	Rotation (sidereal) in hours.	Equatorial diameter in miles.	Apparent Diameter.	
			H. M. S.		Greatest.	Least.
☿	35.393,000	88		2,962	11″·5	4″·5
♀	66,131,000	225		7,510	62·0	9·5
⊕	91,430,000	365	23 56 4	7.901		
♂	139,312,000	687	24 37 23	4,920	23·5	3·3
♃	475,693,000	4,333	9 55 28	85,390	46·0	30·0
♄	879,135,000	10,759	10 29 17	71,904	20·5	14·6
♅	1,753,851,000	30,687		33,024	4·3	3·5
♆	2,746,271,000	60,127		36,620	2·7	2·6

APPENDIX II.

LIST OF DOUBLE STARS, RED STARS, CLUSTERS AND NEBULÆ, ETC., CONTAINED IN PART III. IN ORDER OF RIGHT ASCENSION, 1870.

N.B.—The following positions in R.A., though for the most part given to the nearest second, being derived from various authorities, may not be of uniform accuracy, and when the difference is slight, the relative precedence may hence be sometimes transposed. Some anomalies in nomenclature are the effects of precession. In the present (3d.) impression the Declinations have been added, as frequently convenient to the observer. In a few cases of discrepancy, the data of the Appendix are preferable to those given in the body of the work.

(* *Star.*—N. *Nebula.*—C. *Cluster.*)

Hour 0.

m.	s.			PAGE
2	14	β Cass.	N 58° 26′	224
2	37	Red * Cass.	N 63° 11′	225
3	34	22 And.	N 45° 21′	194
8	16	35 Pisc.	N 8° 10′	283
10	41	38 Pisc.	N 8° 10′	284
13	2	Red * And.	N 43° 56′	195
15	42	42 Pisc.	N 12° 46′	284
25	38	κ Cass.	N 62° 13′	225
25	41	51 Pisc.	N 6° 14′	284
25	47	52 Pisc.	N 19° 35′	284
27	51	P O 113 Cet.	S 5° 16′	229
29	56	π And.	N 33° 0′	193
33	5	55 Pisc.	N 20° 44′	284
33	19	N 105. H v 18 And.	N 40° 59′	196
34	5	P O 146 Cet.	S 5° 4′	229
35	42	N 116. M 31 And. (Great)	N 40° 30′	195
35	42	N 117. M 32 And.	N 40° 9′	196
35	58	C 120. H VIII 78 Cass.	N 61° 5′	226
39	26	P O 175 And.	N 30° 14′	194
41	10	η Cass.	N 57° 8′	223
42	54	65 Pisc.	N 27° 0′	283
45	::	Group Cass.	N 55° 55′	312

Hour O.

m. s.				PAGE
47 59	36 And.	N 22° 56		194
48 51	γ Cass.	N 60° 1′		223
49 31	μ And.	N 37° 51′		193
52 42	Σ 79 And.	N 44° 1′		194
52 44	P O 251 Pisc.	N 0° 5′		284
58 43	ψ^1 Pisc.	N 20° 47′		283
59 5	77 Pisc.	N 4° 13′		284

Hour I.

m. s.				
2 12	N 218 And.	N 35° 1′		196
7 6	ζ Pisc.	N 6° 53′		283
7 49	37 Cet.	S 8° 37′		229
11 32	Polaris	N 88° 37′		301
11 55	φ Cass.	N 57° 33′		225
13 10	42 Cet.	S 1° 11′		229
16 45	ψ Cass.	N 67° 27′		224
21 34	P I 85 Pisc.	N 7° 17′		284
24 37	C 341. M 103 Cass.	N 60° 1′		225
26 31	C 352. M 33 Tri.	N 30° 1′		297
27 57	100 Pisc.	N 11° 54′		284
29 15	P I 123 Pisc.	N 6° 59′		284
34 7	N 385. M 76 Pers.	N 50° 54′		282
35 ::	* * Cet.	S 8° ::		230
36 53	Σ 150 Cet.	S 7° 46′		229
37 18	C 392. H VI 31 Cass.	N 60° 35′		225
37 22	Σ 155 Pisc.	N 8° 50′		285
41 53	Σ 163 Cass.	N 64° 13′		224
42 58	P I 179 Ari. (=Fl. I).	N 21° 38′		207
44 12	χ Cet.	S 11° 20′		229
45 31	Σ 179 And.	N 36° 41′		195
46 23	γ Ari.	N 18° 40′		206
48 25	56 And.	N 36° 37′		193
50 42	λ Ari.	N 22° 58′		206
51 23	58 Cet.	S 2° 42′		229
53 25	Σ 197 Tri.	N 34° 40′		297
54 27	Red * Pers.	N 54° 33′		281
55 19	α Pisc.	N 2° 8′		283

Hour I.

m. s.			PAGE
55 55	γ And.	N 41° 42′	192
56 16	10 Ari.	N 25° 19′	207
57 9	61 Cet.	S 0° 58′	229

Hour II.

m. s.			
2 2	14 Ari.	N 25° 20′	206
3 0	59 And.	N 38° 26′	194
4 19	55 Cass.	N 65° 55′	225
4 49	ι Tri.	N 29° 42′	296
6 8	66 Cet.	S 3° 0′	229
7 8	Σ 232 Tri.	N 29° 47′	297
9 52	Red * And.	N 44° 34′	195
9 52	P II 38 Tri.	N 28° 9′	297
10 2	C 512, 521. ♅ VI 33, 34 Pers.	N 56° 34′	282
12 47	o Cet.	S 3° 34′	228
14 45	P II 61 And.	N 40° 49′	194
18 22	P II 72 Cass.	N 66° 49′	224
20 34	P II 89 Tri.	N 29° 17′	297
24 11	C 553. H 227 Pers.	N 56° 57′	282
29 0	Red * Pers.	N 56° 28′	281
29 3	ν Cet.	N 5° 4′	229
29 27	30 Ari.	N 24° 5′	207
33 4	33 Ari.	N 26° 30′	207
33 40	C 584. M 34 Pers.	N 42° 11′	282
34 3	12 Pers.	N 39° 39′	281
36 2	N 600. M 77 Cet.	S 0° 33′	230
36 34	γ Cet.	N 2° 41′	228
36 54	P II 160 Tri.	N 28° 55′	297
41 14	η Pers.	N 55° 21′	281
42 2	π Ari.	N 16° 55′	206
45 29	20 Pers.	N 37° 49′	281
48 54	P II 191 Ceph.	N 78° 59′	227
51 36	P II 220 Pers.	N 51° 50′	281
51 46	ϵ Ari.	N 20° 49′	206
56 19	ρ^2 Erid.	S 8° 12′	245
57 50	52 Ari.	N 24° 45′	207
59 42	β Pers. (Algol)	N 40° 27′	280

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m.	s.			PAGE
5	57	Σ 362 Cam.	N 59° 33′	215
6	4	C 658. Ȟ VI 25 Pers.	N 46° 45′	282
17	59	Σ 384 Cam.	N 59° 27′	215
18	33	Σ 385 Cam.	N 59° 29′	214
19	44	Σ 389 Cam.	N 58° 55′	215
23	8	Σ 396 Cam.	N 58° 19′	215
23	30	Σ 401 Taur.	N 27° 8′	295
24	24	Σ 400 Cam.	N 59° 36′	215
26	44	7 Taur.	N 24° 2′	294
30	::	Red * Cam.	N 62° 15′	215
30	7	P III 98 Erid.	N 0° 10′	245
31	54	Σ 425 Pers.	N 33° 42′	281
32	::	Red * Pers.	N 47° 19′	282
32	0	P III 97 Cam.	N 59° 33′	215
34	55	Red * Taur.	N 14° 21′	295
36	13	Red * Pers.	N 53° 28′	282
38	7	Σ 443 Pers.	N 41° 5′	281
38	28	N 768 Taur.	N 23° 20′	296
39	34	C 775. Ȟ VIII 80 Pers.	N 52° 16′	281
39	45	η Taur. (Pleiades)	N 23° 42′	293
41	8	30 Taur.	N 10° 45′	294
45	57	ζ Pers.	N 31° 30′	280
47	50	32 Erid.	S 3° 20′	245
49	8	ε Pers.	N 39° 38′	280
53	11	P III 213 Taur.	N 22° 50′	294
56	1	N 801. Ȟ IV 53 Cam.	N 60° 29′	215

Hour IV.

m.	s.			
0	20	Σ 495 Taur.	N 14° 49′	295
5	22	C 820. Ȟ VII 61 Pers.	N 50° 53′	282
8	13	39 Erid.	S 10° 35′	245
8	14	N 826. Ȟ IV 26 Erid.	S 13° 4′	245
9	23	40 Erid.	S 7° 50′	245
12	21	φ Taur.	N 27° 2′	294
14	40	χ Taur.	N 25° 19′	294
15	58	Σ 533 Pers.	N 34° 1′	281
16	9	62 Taur.	N 24° 0′	294

Hour IV.

m. s.			PAGE
17 37	κ^1 Taur.	N 22° 0′	295
20 40	Σ 548 Taur.	N 30° 4′	295
21 8	θ^1 Taur.	N 15° 40′	293
21 44	1 Cam.	N 53° 38′	214
22 31	Σ 552 Pers.	N 39° 44′	281
22 43	80 Taur.	N 15° 21′	294
24 16	57 Pers.	N 42° 47′	281
26 2	Σ 559 Taur.	N 17° 44′	295
27 41	58 Pers.	N 41° 0′	281
28 28	Aldebaran	N 16° 14′	293
28 31	88 Taur.	N 9° 54′	293
29 39	2 Cam.	N 53° 13′	214
30 27	Σ 572 Aur.	N 26° 41′	209
31 44	σ^1 Taur.	N 15° 32′	295
34 26	τ Taur.	N 22° 42′	293
36 50	Red * Aur.	N 32° 41′	209
37 20	55 Erid.	S 9° 2′	245
43 23	Red * Aur.	N 28° 18′	209
46 52	Σ 610 Cam.	N 53° 33′	214
50 0	62 Erid.	S 5° 23′	245
50 25	ω Aur.	N 37° 42′	208
51 21	P IV 258 Ori.	N 1° 28′	274
51 37	P IV 257 Taur.	N 14° 21′	294
51 52	β Cam.	N 60° 16′	215
53 14	R Lep.	S 15° 1′	258
53 44	Σ 627 Ori.	N 3° 25′	274
54 51	11 Cam.	N 58° 43′	214
55 16	P IV 278 Ori.	N 1° 25′	274
58 41	Red * Ori.	N 0° 59′	275

Hour V.

m. s.			
1 10	P IV 269 Cam.	N 79° 5′	214
1 31	Σ 644 Aur.	N 37° 8′	209
6 14	ι Lep.	S 12° 1′	258
6 29	ρ^1 Ori.	N 2° 42′	273
6 32	14 Aur.	N 32° 32′	208
7 6	Capella	N 45° 52′	207

Hour V.

m.	s.				PAGE
7	14	κ Lep.	S	13° 6′	258
8	17	Rigel.	S	8° 21′	272
9	8	P V 20 Taur.	N	18° 18′	295
9	38	16 Aur.	N	33° 14′	208
11	6	C 1067. H VII 33 Aur.	N	39° 12′	210
11	34	P V 37 Taur.	N	20° 0′	294
12	15	Red * Aur.	N	34° 8′	209
15	59	23 Ori.	N	3° 25′	273
16	49	111 Taur.	N	17° 16′	294
17	56	η Ori.	S	2° 31′	273
18	26	P V 84 Ori.	N	1° 48′	274
19	2	φ Aur.	N	34° 22′	209
19	4	C 1112. M 79 Lep.	S	24° 38′	258
20	2	ψ^2 Ori.	N	2° 59′	273
20	41	C 1119. M 38 Aur.	N	35° 47′	209
21	15	118 Taur.	N	25° 3′	294
22	21	Σ 718 Aur.	N	49° 22′	209
23	::	S Ori.	S	4° 48′	275
23	8	31 Ori.	S	1° 12′	274
23	49	32 Ori.	N	5° 51′	273
24	25	33 Ori.	N	3° 12′	274
24	42	Σ 730 Taur.	N	16° 58′	295
25	22	δ Ori.	S	0° 24′	272
26	39	N 1157. M 1 Taur.	N	21° 56′	295
27	43	C 1166. M 36 Aur.	N	34° 3′	209
27	58	λ Ori.	N	9° 51′	272
28	38	Σ 742 Taur.	N	21° 55′	295
28	41	Σ 747 Ori.	S	6° 5′	274
28	53	N 1179. M 42 Ori. (Great)	S	5° 29′	275
29	1	Σ 749 Taur.	N	26° 51′	295
29	4	ι Ori.	S	6° 0′	272
29	5	Σ 750 Ori.	S	4° 27′	274
29	5	C 1184. H 362 Ori.	S	4° 26′	275
30	::	* * Ori.	N	3° 40	275
30	16	26 Aur.	N	30° 25′	208
30	51	Σ 757 Ori.	S	0° 19′	274
31	42	Σ 758 Ori.	S	0° 19′	274
32	13	σ Ori.	S	2° 40′	273

Hour V.

m.	s.			PAGE
34	12	ζ Ori.	S 2° 1′	272
39	4	γ Lep.	S 22° 29′	258
39	36	Σ 790 Ori.	S 4° 10′	274
40	5	N 1267. M 78 Ori.	0° 0′	277
41	1	52 Ori.	N 6° 25′	273
42	28	P V 225 Aur.	N 31° 45′	208
43	44	C 1295. M 37 Aur.	N 32° 31′	209
44	3	Σ 809 Ori.	S 1° 28′	274
48	8	Betelgeuze	N 7° 23′	271
55	43	3 Mon.	S 10° 36′	266

Hour VI.

m.	s.			
0	51	C 1360. M 35 Gem.	N 24° 21′	248
1	7	C 1361. H VIII 24 Ori.	N 13° 59′	275
1	39	41 Aur.	N 48° 44′	208
2	19	4 Mon.	S 11° 7′	267
2	39	Σ 859 Ori.	N 5° 41′	274
2	49	Red * Gem.	N 26° 3′	247
5	24	Red * Aur.	N 27° 12′	209
6	54	Σ 872 Aur.	N 36° 11′	208
7	2	η Gem.	N 22° 32′	247
8	31	5 Mon.	S 6° 14′	267
10	31	4 Lyn.	N 59° 25′	261
13	51	Σ 895 Ori.	N 5° 48′	274
15	5	μ Gem.	N 22° 35′	246
16	52	8 Mon.	N 4° 39′	266
20	1	15 Gem.	N 20° 52′	247
20	2	P VI 104 Mon.	N 0° 32′	266
21	32	10 Mon.	S 4° 41′	267
22	31	11 Mon.	S 6° 57′	266
24	1	C 1424. H VII 2 Mon.	N 5° 2′	267
24	42	20 Gem.	N 17° 52′	247
25	53	13 Mon.	N 7° 26′	267
27	36	Red * Aur.	N 38° 34′	209
29	28	Σ 941 Aur.	N 41° 41′	209
30	12	γ Gem.	N 16° 31′	246
30	42	ν^1 Can. Maj.	S 18° 33′	220

Hour VI.

m. s.				PAGE
33 22	P VI 174 Lyn. . .	N 59° 34′	. . .	261
33 49	15 Mon. . . .	N 10° 1′	. . .	266
34 45	12 Lyn. . . .	N 59° 34′	. . .	260
35 56	ε Gem. . . .	N 25° 15′	. . .	246
36 8	* * Can. Maj. . .	S 15° 53′	. . .	220
37 21	Σ 958 Lyn. . .	N 55° 51′	. . .	261
37 22	56 Aur. . . .	N 43° 42′	. . .	208
39 26	Sirius . . .	S 16° 32′	. . .	219
41 12	C 1454. M 41 Can. Maj.	S 20° 37′	. . .	220
41 37	14 Lyn. . . .	N 59° 36′	. . .	260
45 5	C 1465. Ḫ VI 27 Mon.	N 0° 37′	. . .	267
47 18	38 Gem. . . .	N 13° 21′	. . .	247
50 8	μ Can. Maj. . .	S 13° 53′	. . .	220
55 16	P VI 301 Lyn. . .	N 52° 57′	. . .	260
56 24	ζ Gem. . . .	N 20° 46′	. . .	246
56 37	C 1483. M 50 Mon. .	S 8° 9′	. . .	267
59 32	R Gem. . . .	N 22° 54′	. . .	247

Hour VII.

m. s.				
11 57	C 1512. Ḫ VII 12 Can. Maj.	S 15° 24′	. . .	220
12 14	19 Lyn. . . .	N 55° 32′	. . .	261
12 17	20 Lyn. . . .	N 50° 23′	. . .	261
12 22	δ Gem. . . .	N 22° 13′	. . .	246
13 18	30 Can. Maj. . .	S 24° 43′	. . .	220
15 47	Red * Mon. . .	S 20° 40′	. . .	267
19 17	61 Gem. . . .	N 20° 31′	. . .	247
20 ::	H 264 Gem. . .	N 22° 25′	. . .	247
21 30	N 1532. Ḫ IV 45 Gem.	N 21° 10′	. . .	248
21 46	P VII 116 Mon. .	S 11° 18′	. . .	266
25 40	S Can. Min. . .	N 8° 36′	. . .	221
26 19	Castor . . .	N 32° 10′	. . .	246
28 49	P VII 149 Arg. .	S 23° 11′	. . .	204
30 34	C 1551. Ḫ VIII 38 Arg.	S 14° 12′	. . .	205
30 41	C 1549. Ḫ VI 1 Gem.	N 21° 52′	. . .	248
32 30	Procyon . . .	N 5° 34′	. . .	220
33 13	P VII 170 Can. Min.	N 5° 32′	. . .	221
33 30	P VII 159 Cam. .	N 65° 28′	. . .	214
33 31	P VII 175 Arg. .	S 26° 30′	. . .	205

Hour VII.

m.	s.			PAGE
35	52	C 1564. M 46 Arg.	S 14° 31′	205
36	6	N 1567. ♅ IV 64 Arg.	S 17° 54′	206
36	39	K Gem.	N 24° 41′	247
39	0	C 1571. M 93 Arg.	S 23° 33′	205
39	31	2 Arg.	S 14° 23′	205
41	52	5 Arg.	S 11° 53′	205
47	23	U Gem.	N 22° 21′	247
51	37	14 Can. Min.	N 2° 34′	221
53	4	ω^1 Canc.	N 25° 45′	312
53	48	C 1611. ♅ VI 37 Arg.	S 10° 25′	205
55	32	6 Canc.	N 28° 9′	217
57	39	Σ 1177 Canc.	N 27° 54′	216

Hour VIII.

m.	s.			
1	17	Σ 1187 Lyn.	N 32° 36′	313
2	4	29 Mon.	S 2° 36′	266
4	35	C 1630. ♅ VII 11 Arg.	S 12° 29′	205
4	45	ζ Canc.	N 18° 2′	216
7	9	C 1637. ♅ VI 22 Mon.	S 5° 24′	267
18	55	ϕ^2 Canc.	N 27° 23′	216
18	55	υ^1 Canc.	N 25° 0′	216
19	27	P VIII 72 Arg.	S 23° 38′	204
19	45	Σ 1228 Canc.	N 27° 59′	216
21	26	P VIII 81 Mon.	S 2° 5′	266
28	56	P VIII 108 Hyd.	N 7° 4′	253
32	46	C 1681. M 44 Canc.	N 20° 24′	217
34	13	P VIII 131 Lyn.	N 49° 20′	261
37	17	31 Mon.	S 6° 46′	267
38	47	P VIII 160 Hyd.	S 2° 8′	253
38	49	ι Canc.	N 29° 14′	216
39	54	ϵ Hyd.	N 6° 54′	253
44	5	C 1712. M 67 Canc.	N 12° 17′	217
44	36	N 1713. ♅ I 200 Leon. Min.	N 33° 54′	257
46	18	σ^2 Canc.	N 31° 4′	215
48	3	Red * Canc.	N 17° 46′	217
49	7	17 Hyd.	S 7° 29′	253
50	18	ι Urs. Maj.	N 48° 33′	299
53	26	σ^4 Canc.	N 32° 48′	216

Hour VIII.

m. s.			PAGE
58 56	σ^2 Urs. Maj. . .	N 67° 40′	299
59 58	Σ 1311 Canc. . .	N 23° 30′	216

Hour IX.

m. s.			
10 45	38 Lyn.	N 37° 21′	260
12 51	Σ 1338 Lyn. . .	N 38° 47′	261
13 8	40 Lyn.	N 34° 56′	261
13 39	39 Lyn.	N 50° 6′	261
14 24	N 1823. H I 205 Urs. Maj.	N 51° 33′	301
16 25	21 Urs. Maj. . .	N 54° 34′	300
16 30	P IX 65 Hyd. . .	N 4° 3′	253
20 8	41 Lyn.	N 46° 10′	261
21 15	23 Urs. Maj. . .	N 63° 38′	299
22 33	τ^1 Hyd.	S 2° 12′	253
25 0	6 Leon.	N 10° 17′	255
40 34	R Leon.	N 12° 2′	256
44 44	NN 1949, 1950. M 81, 82 Urs. Maj. . .	N 69° 44′	300
47 19	9 Sext.	N 5° 33′	292
58 46	N 2008. H I 163 Sext.	S 7° 6′	292

Hour X.

m. s.			
1 27	Regulus	N 12° 36′	255
7 24	Σ 1415 Urs. Maj. .	N 71° 43′	300
7 32	N 2041. H I 4 Sext. .	N 4° 6′	292
12 47	γ Leon.	N 20° 30′	255
17 47	P X 58 Urs. Maj. .	N 53° 17′	300
18 27	N 2102. H IV 27 Hyd.	S 18° 0′	254
18 44	P X 67 Leon. . .	N 9° 26′	256
20 7	Σ 1434 Leon. . .	N 18° 40′	256
28 13	49 Leon.	N 9° 19′	255
36 36	35 Sext.	N 5° 26′	292
41 13	Σ 1474 Hyd. . .	S 14° 23′	253
41 14	P X 159 Hyd. . .	S 14° 56′	253
41 24	N 2207. H I 18 Leon.	N 13° 19′	257
48 34	54 Leon.	N 25° 27′	255
53 27	α Crat.	S 17° 24′	235
55 41	α Urs. Maj. . .	N 62° 27′	298

Hour XI.

m. s.				PAGE
0 22	P X 239 Leon.	N	7° 50′	256
3 49	N 2318. H v 46 Urs. Maj.	N	56° 22′	301
6 44	Σ 1516 Drac.	N	74° 11′	243
6 53	P XI 9 Leon.	N	20° 51′	256
7 10	N 2343. M 97 Urs. Maj.	N	55° 43′	301
11 15	ξ Urs. Maj.	N	32° 16′	299
11 27	ν Urs. Maj.	N	33° 45′	299
13 9	P XI 39 Crat.	S	6° 11′	235
13 22	NN 2377, 2373. M 66, 65 Leon.	N	13° 43′	257
17 9	ι Leon.	N	11° 15′	255
20 12	83 Leon.	N	3° 43′	256
22 4	57 Urs. Maj.	N	40° 6′	299
24 15	P XI 91 Leon.	S	6° 0′	256
25 3	88 Leon.	N	15° 5′	256
25 50	17 Crat.	S	28° 33′	234
27 57	90 Leon.	N	17° 31′	255
29 27	P XI 111 Urs. Maj.	N	28° 30′	299
31 30	Σ 1559 Urs. Maj.	N	65° 4′	300
31 46	P XI 126 Virg.	S	1° 43′	303
31 57	Σ 1561 Urs. Maj.	N	45° 50′	300
42 27	β Leon.	N	15° 18′	255
48 19	65 Urs. Maj.	N	47° 12′	299
57 37	2 Com.	N	22° 11′	231

Hour XII.

m. s.				
4 13	Σ 1606 Can. V.	N	40° 37′	218
9 37	2 Can. V.	N	41° 26′	217
10 33	Σ 1625 Cam.	N	80° 51′	215
11 29	P XII 32 Virg.	S	3° 14′	304
12 13	N 2838. M 99 Virg.	N	15° 15′	305
12 34	N 2841. H v 43 Urs. Maj.	N	48° 1′	301
14 9	Σ 1633 Com.	N	27° 47′	231
15 56	17 Virg.	N	6° 2′	303
15 58	12 Com.	N	26° 34′	231
18 50	N 2946. M 85 Com.	N	18° 55′	232
22 25	17 Com.	N	26° 38′	231
23 7	N 3021. M 49 Virg.	N	8° 43′	305
23 8	δ Corv.	S	15° 47′	234

Hour XII.

m.	s.				PAGE
24	::	* * Virg.	N	2° 30′	304
25	25	N 3049. M 88 Virg.	N	15° 8′	305
27	34	β Corv.	S	22° 41′	234
28	36	24 Com.	N	19° 6′	231
29	53	N 3106. Ⲏ v 24 Com.	N	26° 42′	232
33	13	N 3132. Ⲏ I 43 Virg.	S	10° 54′	304
34	31	Σ 1669 Virg.	S	12° 18′	304
35	5	γ Virg.	S	0° 44′	302
37	4	N 3182. M 60 Virg.	N	12° 16′	304
44	37	P XII 196 Virg.	S	9° 38′	303
44	47	N 3258. M 94 Can. V.	N	41° 50′	218
45	28	P XII 202 Com.	N	19° 53′	231
46	20	N 3278. Ⲏ II 75 Virg.	N	11° 56′	305
46	54	35 Com.	N	21° 57′	231
48	17	P XII 232 Cam.	N	84° 7′	214
48	59	P XII 221 Virg.	N	12° 12′	304
49	57	12 Can. V.	N	39° 4′	217
50	::	* * Urs. Maj.	N	54° 48′	300
50	21	N 3321. M 64 Com.	N	22° 23′	232

Hour XIII.

m.	s.				
3	13	θ Virg.	S	4° 51′	303
6	31	54 Virg.	S	18° 8′	303
6	31	C 1558. M 53 Com.	N	18° 52′	232
8	8	P XIII 25 Virg.	S	10° 40′	304
9	59	N 3474. M 63 Can. V.	N	42° 43′	218
18	41	ζ Urs. Maj.	N	55° 36′	298
22	36	R Hyd.	S	22° 36′	254
22	44	* * Drac.	N	65° 28′	243
24	22	N 3572. M 51 Can. V.	N	47° 52′	218
27	39	P XIII 127 Virg.	N	0° 21′	304
27	46	Var. near Spica.	S	12° 32′	304
30	47	81 Virg.	S	7° 13′	304
32	31	P XIII 156 Urs. Maj.	N	51° 26′	299
34	28	1 Boöt.	N	20° 37′	213
35	49	83 Urs. Maj.	N	55° 17′	300
36	8	C 3636. M 3 Can. V.	N	29° 1′	218
36	33	84 Virg.	N	4° 12′	303

Hour XIII.

m. s.			PAGE
36 47	P XIII 171 Virg. .	S 3° 37′ . . .	304
43 11	Σ 1785 Boöt. . .	N 27° 38′ . . .	213
44 16	P XIII 220 Boöt. .	N 21° 55′ . . .	213
48 9	P XIII 238 Virg. .	S 7° 25′ . . .	303
53 7	Σ 1793 Boöt. . .	N 26° 27′ . . .	213
54 9	P XIII 277 Urs. Maj.	N 53° 44′ . . .	300

Hour XIV.

m. s.			
8 48	κ Boöt. . . .	N 52° 24′ . . .	212
9 42	Arcturus. . . .	N 19° 52′ . . .	210
10 31	Σ 1825 Boöt. . .	N 20° 44′ . . .	213
11 34	ι Boöt. . . .	N 51° 58′ . . .	212
15 46	P XIV 62 Lib. . .	S 7° 10′ . . .	259
16 59	P XIV 69 Boöt. .	N 9° 2′ . . .	212
17 42	P XIV 70 Lib. . .	S 11° 5′ . . .	259
18 20	Red * Boöt. . .	N 26° 21′ . . .	312
21 31	φ Virg. . . .	S 1° 39′ . . .	303
22 47	C 3900. H I 70 Virg.	S 5° 23′ . . .	304
22 50	Σ 1850 Boöt. . .	N 28° 52′ . . .	213
34 36	π Boöt. . . .	N 16° 59′ . . .	211
34 56	ζ Boöt. . . .	N 14° 17′ . . .	211
38 20	10 Hyd. . . .	S 24° 53′ . . .	253
38 25	Σ 1873 Boöt. . .	N 8° 15′ . . .	213
39 19	ε Boöt. . . .	N 27° 37′ . . .	211
42 38	Σ 1884 Boöt. . .	N 24° 54′ . . .	213
42 26	Σ 1883 Boöt. . .	N 6° 30′ . . .	213
43 40	α^2 Lib. . . .	S 15° 30′ . . .	259
45 17	39 Boöt. . . .	N 49° 15′ . . .	212
45 22	ξ Boöt. . . .	N 19° 39′ . . .	211
49 47	P XIV 212 Lib. .	S 20° 48′ . . .	259
54 2	δ Lib. . . .	S 7° 50′ . . .	260
54 46	N 4029. H II 756 Boöt.	N 54° 24′ . . .	214
59 31	44 Boöt. . . .	N 48° 10′ . . .	212

Hour XV.

m. s.			
1 16	P XIV 279 Boöt. .	N 9° 43′ . . .	213
6 57	Σ 1919 Boöt. . .	N 19° 46′ . . .	213
7 7	P XV 14 Lib. . .	S 17° 56′ . . .	259

Hour XV.

m.	s.				PAGE
10	1	β Lib.	S	8° 54′	259
10	15	δ Boöt.	N	33° 48′	211
11	57	C 4083. M 5 Lib.	N	2° 35′	260
12	39	5 Serp.	N	2° 0′	291
12	46	Σ 1932 Cor.	N	27° 19′	233
14	25	6 Serp.	N	1° 11′	291
17	50	η Cor.	N	30° 46′	232
19	35	μ^1 Boöt.	N	37° 50′	211
24	15	P XV 91 Lib.	S	19° 43′	259
27	41	θ Cor.	N	31° 46′	233
28	36	δ Serp.	N	10° 58′	290
31	39	Σ 1962 Lib.	S	8° 22′	259
34	29	ζ Cor.	N	37° 4′	232
35	27	P XV 150 Lib.	S	15° 36′	259
36	51	π^1 Urs. Min.	N	80° 53′	302
37	51	α Serp.	N	6° 48′	290
40	11	β Serp.	N	15° 50′	290
45	48	2 Scorp.	S	24° 56′	289
46	50	π^2 Urs. Min.	N	80° 23′	302
50	45	P XV 220 Serp.	N	3° 47′	291
54	4	T Cor.	N	26° 18′	233
55	24	5 Herc.	N	18° 8′	251
57	14	ξ Scorp.	S	11° 1′	289
57	52	β Scorp.	S	19° 27′	289

Hour XVI.

m.	s.				
0	3	11 Scorp.	S	12° 24′	289
2	12	κ^1 Herc.	N	17° 24′	250
4	26	ν Scorp.	S	19° 7′	289
6	9	Σ 2017 Serp.	N	14° 53′	291
7	14	49 Serp.	N	13° 53′	291
9	15	C 4173. M 80 Scorp.	S	22° 40′	289
9	49	σ Cor.	N	34° 11′	233
12	54	P XVI 48 Scorp.	S	19° 48′	289
13	17	σ Scorp.	S	25° 17′	289
15	40	N 4183. M 4 Scorp.	S	26° 12′	290
17	35	ν^2 Cor.	N	34° 0′	232
17	47	ρ Oph.	S	23° 8′	269

Hour XVI.

m. s.				PAGE
17 57	23 Herc. . . .	N 32° 38′	. . .	250
21 24	Antares. . . .	S 26° 9′	. . .	288
22 12	η Drac. . . .	N 61° 48′	. . .	242
24 22	λ Oph. . . .	N 2° 16′	. . .	268
29 36	P XVI 125 Herc. .	N 17° 20′	. . .	251
30 47	C 4315. M 14 Oph. .	S 3° 10′	. . .	270
33 10	17 Drac. . . .	N 53° 11′	. . .	242
34 9	Σ 2079 Herc. . .	N 23° 15′	. . .	251
35 13	42 Herc. . . .	N 49° 11′	. . .	250
36 24	ζ Herc. . . .	N 31° 50′	. . .	249
37 2	C 4230. M 13 Herc. .	N 36° 42′	. . .	251
37 8	Σ 2087 Herc. . .	N 23° 54′	. . .	251
39 1	N 4234. Σ 5 Herc. .	N 24° 2′	. . .	252
39 54	46 Herc. . . .	N 28° 36′	. . .	251
40 29	C 4238. M 12 Oph. .	S 1° 44′	. . .	270
40 37	19 Oph. . . .	N 2° 18′	. . .	269
43 13	N 4244. ♅ IV 50 Herc.	N 47° 46′	. . .	253
44 50	21 Oph. . . .	N 1° 26′	. . .	270
49 25	P XVI 236 Scorp. .	S 19° 20′	. . .	289
49 43	56 Herc. . . .	N 25° 56′	. . .	251
50 19	C 4256. M 10 Oph. .	S 3° 55′	. . .	270
52 13	Hind's * Oph. .. .	S 12° 41′	. . .	270
54 35	N 4264. M 19 Oph. .	S 26° 5′	. . .	270
55 17	20 Drac. . . .	N 65° 20′	. . .	243
55 44	P XVI 270 Oph. .	N 8° 38′	. . .	269
59 36	Σ 2120 Herc. . .	N 28° 16′	. . .	251

Hour XVII.

m. s.				
2 39	μ Drac. . . .	N 54° 39′	. . .	242
7 20	36 Oph. . . .	S 26° 24′	. . .	268
8 43	α Herc. . . .	N 14° 32′	. . .	249
9 35	31 Scorp. . . .	S 26° 29′	. . .	289
9 42	δ Herc. . . .	N 25° 0′	. . .	249
9 57	39 Oph. . . .	S 24° 9′	. . .	269
11 27	C 4287. M 9 Oph. .	S 18° 23′	. . .	271
13 9	C 4294. M 92 Herc. .	N 43° 16′	. . .	252
13 30	ν Serp. . . .	S 12° 43′	. . .	291

Hour XVII.

m.	s.				PAGE
19	12	ρ Herc.	N	37° 16′	249
21	48	Σ 2166 Oph.	N	11° 30′	270
25	29	λ Herc.	N	26° 13′	250
25	50	P XVII 147 Drac.	N	50° 58′	242
28	26	53 Oph.	N	9° 41′	269
29	36	ν^1 Drac.	N	55° 16′	242
30	47	C 4315. M 14 Oph.	S	3° 10′	270
32	53	Σ 2191 Oph.	S	4° 54′	270
35	45	P XVII 200 Herc.	N	24° 35′	251
38	2	61 Oph.	N	2° 38′	269
39	29	Σ 2218 Drac.	N	63° 44′	243
42	23	μ Herc.	N	27° 48′	250
43	::	* * Oph.	N	5° 1′	270
44	14	ψ^1 Drac.	N	72° 13′	242
47	37	Red * Oph.	N	1° 47′	270
49	18	C 4346. M 23 Oph.	S	18° 59′	270
50	42	P XVII 300 Herc.	N	18° 21′	251
53	32	ν Herc.	N	30° 12′	251
54	8	67 Oph.	N	2° 56′	268
55	::	* * Taur. P.	N	7° 45′	296
55	55	N 4361. M 8 Sagittar.	S	24° 21′	287
55	59	95 Herc.	N	21° 36′	250
56	0	τ Oph.	S	8° 11′	269
56	50	C 4367. M 21 Sagittar.	S	22° 31′	287
58	40	N 4373. ♅ IV 37 Drac.	N	66° 38′	243
58	52	70 Oph.	N	2° 32′	268
59	40	P XVII 362 Taur. P.	N	12° 0′	296

Hour XVIII.

m.	s.				
2	34	100 Herc.	N	26° 5′	251
3	6	73 Oph.	N	3° 58′	269
4	56	C 4388. ♅ VII 30 Sagittar.	S	21° 36′	287
5	56	μ^1 Sagittar.	S	21° 5′	286
9	46	40 Drac.	N	79° 59′	242
10	34	C 4397. M 24 Clyp.	S	18° 27′	230
11	26	C 4400. M 16 Clyp.	S	13° 50′	230
12	20	C 4401. M 18 Clyp.	S	17° 11′	230

Hour XVIII.

m.	s.				PAGE
13	7	N 4403. M 17 Clyp. .	S	16° 15′	. . . 230
16	32	C 4406. M 28 Sagittar.	S	24° 56′	. . . 287
17	37	21 Sagittar. . .	S	20° 37′	. . . 286
19	57	λ Sagittar. . .	S	25° 29′	. . . 286
20	32	59 Serp. . . .	N	0° 7′	. . . 291
21	12	C 4410. ꟗ VIII 72 Serp.	N	6° 29′	. . . 291
22	2	39 Drac. . . .	N	58° 43′	. . . 242
24	0	C. M 25 Sagittar. .	S	19° 9′	. . . 287
28	15	C 4424. M 22 Sagittar.	S	24° 0′	. . . 286
31	0	Σ 2348 Drac. . .	N	52° 15′	. . . 242
32	30	Wega. . . .	N	38° 40′	. . . 262
33	50	P XVIII 151 Lyr. .	N	35° 56′	. . . 264
37	27	Σ 2372 Lyr. . .	N	34° 37′	. . . 264
38	5	C 4432. M 26 Clyp. .	S	9° 32′	. . . 230
39	5	Σ 2375 Taur. P. .	N	5° 22′	. . . 296
39	46	5 Aquil. . . .	S	1° 6′	. . . 202
40	1	ε Lyr. . . .	N	39° 32′	. . . 263
40	3	110 Herc. . . .	N	20° 26′	. . . 250
40	7	46 Drac. . . .	N	55° 24′	. . . 243
40	17	ζ Lyr. . . .	N	37° 28′	. . . 263
42	43	P XVIII 197 Ant. .	S	6° 3′	. . . 197
42	46	Σ 2403 Drac. . .	N	60° 55′	. . . 243
42	46	Red * Clyp. . .	S	8° 3′	. . . 230
44	9	C 4437. M 11 Ant. .	S	6° 25′	. . . 198
44	39	Σ 2404 Taur. P. .	N	10° 50′	. . . 296
45	15	β Lyr. . . .	N	33° 13′	. . . 262
48	44	N 4447. M 57 Lyr. .	N	32° 52′	. . . 265
49	11	δ Lyr. . . .	N	36° 48′	. . . 264
49	16	ο Drac. . . .	N	59° 14′	. . . 242
49	45	θ Serp. . . .	N	4° 2′	. . . 290
49	50	C 4451. H 2024 Aquil.	N	10° 11′	. . . 204
50	7	B.A.C. 6468 Lyr. .	N	33° 48′	. . . 265
53	7	11 Aquil. . . .	N	13° 27′	. . . 202
53	44	ε Aquil. . . .	N	14° 54′	. . . 312
54	2	P XVIII 263 Aquil. .	N	14° 44′	. . . 203
56	4	P XVIII 274 Ant. .	S	0° 53′	. . . 198
57	27	Red * Aquil. (or Ant.)	S	5° 53′	. . . 204
58	6	15 Aquil. . . .	S	4° 13′	. . . 201

Hour XVIII.

m. s.			PAGE
59 11	1 Vulp. . . .	N 23° 8′	306
59 27	P XVIII 302 Aquil. .	N 6° 21′	203

Hour XIX.

m. s.			
2 31	17 Lyr. . . .	N 32° 18′	264
4 3	P XIX 13 Lyr. . .	N 37° 42′	264
8 45	Σ 2486 Cyg. . .	N 49° 36′	239
9 19	η Lyr. . . .	N 38° 55′	264
11 29	C 4485. M 56 Lyr. .	N 29° 57′	265
11 52	θ Lyr. . . .	N 37° 54′	264
11 55	23 Aquil. . . .	N 0° 51′	202
13 36	26 Ant. . . .	S 5° 39′	198
14 ::	Red * Sagittæ . .	N 27° 1′	285
19 47	4 Ans. . . .	N 19° 33′	197
23 0	P XIX 149 Cyg. .	N 36° 16′	238
23 18	6 Ans. . . .	N 24° 24′	197
23 39	P XIX 144 Aquil. .	N 2° 38′	203
25 ::	* * Cyg. . . .	N 28° 27′	239
25 29	β Cyg. . . .	N 27° 41′	235
26 51	Red * Sagittar. . .	S 16° 40′	286
27 ::	* * Cyg. . . .	N 28° 0′	239
27 58	37 Ant. . . .	S 10° 50′	198
31 24	ε Sagittæ . . .	N 16° 10′	285
32 57	θ Cyg. . . .	N 49° 55′	239
33 16	54 Sagittar. . .	S 16° 35′	286
36 29	P XIX 241 Aquil. .	N 8° 4′	203
36 38	N 4510. Ɦ IV 51 Sagittar.	S 14° 28′	287
38 0	P XIX 250 Aquil. .	N 12° 4′	204
38 22	16 Cyg. . . .	N 50° 13′	238
38 46	P XIX 257 Aquil. .	N 10° 28′	203
40 3	γ Aquil. . . .	N 10° 18′	201
40 53	P XIX 276 Cyg. .	N 35° 47′	238
40 54	δ Cyg. . . .	N 44° 49′	236
41 0	P XIX 278 Cyg. .	N 34° 42′	238
41 25	Ɦ 640 Cyg. . .	N 32° 46′	312
41 29	χ Cyg. . . .	N 33° 26′	236
42 35	π Aquil. . . .	N 11° 28′	201

Hour XIX.

m.	s.				PAGE
43	13	ζ Sagittæ	N	18° 49′	285
44	24	Al Tair	N	8° 32′	201
44	51	η Ant.	N	0° 38′	197
46	4	P XIX 307 Aquil.	N	10° 2′	203
47	35	57 Aquil.	S	8° 34′	202
47	39	P XIX 320 Vulp.	N	20° 0′	305
47	56	C 4520. M 71 Sagittæ	N	18° 27′	285
48	36	ε Drac.	N	69° 56′	242
52	17	ψ Cyg.	N	52° 6′	238
53	::	Red * Cyg.	N	43° 55′	239
53	34	Σ 2607 Cyg.	N	41° 55′	239
53	57	N 4532. M 27 Vulp.	N	22° 22′	306
58	24	N 4543. M 75 Sagittar.	S	22° 17′	287

Hour XX.

m.	s.				
1	31	P XIX 415 Vulp.	N	20° 44′	306
3	13	P XX 2 Aquil.	N	16° 32′	202
4	12	θ Sagittæ	N	20° 32′	285
4	38	P XX 12 Ant.	S	0° 31′	198
5	57	P XX 26 Ant.	N	0° 29′	197
7	47	P XX 43 Aquil.	N	6° 11′	203
8	22	Σ 2654 Ant.	S	3° 54′	198
9	::	* * Cyg.	N	41° 35′	312
9	::	Red * Cyg.	N	38° 20′	239
9	30	Red * Capr.	S	21° 45′	222
9	33	o^2 Cyg.	N	46° 21′	236
10	50	α Capr.	S	12° 57′	221
11	27	32 Cyg.	N	47° 19′	240
11	54	σ Capr.	S	19° 31′	222
13	7	Σ 2661 Ant.	S	2° 39′	198
13	15	κ Ceph.	N	77° 19′	226
13	31	Σ 2666 Cyg.	N	40° 20′	239
13	42	β^2 Capr.	S	15° 11′	222
15	12	Σ 2671 Cyg.	N	54° 59′	239
15	38	U Cyg.	N	47° 30′	239
18	0	P XX 116 Ant.	N	0° 39′	197
18	27	C 4575. ♅ VIII 56 Cyg.	N	40° 18′	239

Hour XX.

m.	s.					PAGE
19	52	π Capr.	S	18°	38′	222
20	44	P XX 140 Ant.	S	2°	32′	197
21	27	ρ Capr.	S	18°	14′	222
21	37	68 Aquil.	S	3°	47′	204
22	26	o^2 Capr.	S	19°	1′	222
25	1	P XX 178 Del.	N	10°	50′	241
27	19	ω^2 Cyg.	N	48°	47′	237
27	49	N 4585. H I 103 Del.	N	6°	59′	241
31	27	β Del.	N	14°	9′	241
32	33	Σ 2705 Cyg.	N	32°	55′	239
32	36	θ Del.	N	12°	52′	241
33	36	α Del.	N	15°	27′	241
33	45	Σ 2708 Cyg.	N	38°	11′	239
35	47	49 Cyg.	N	31°	51′	238
36	::	* * Capr.	S	16°	::′	222
40	18	52 Cyg.	N	30°	15′	238
40	38	γ Del.	N	15°	40′	240
41	22	13 Del.	N	5°	33′	241
42	::	* * Cyg.	N	42°	3′	313
46	19	P XX 355 Eq.	N	6°	51′	244
49	10	P XX 376 Eq.	N	4°	2′	244
52	35	ε Eq.	N	3°	48′	244
54	21	P XX 429 Cyg.	N	49°	57′	238
55	48	λ Eq.	N	6°	40′	244
57	5	N 4628. H IV 1 Aquar.	S	11°	52′	200
57	12	12 Aquar.	S	6°	20′	199
57	22	P XX 452 Cyg.	N	39°	0′	238
58	34	Σ 2751 Ceph.	N	56°	9′	227

Hour XXI.

m.	s.					
0	53	61^1 Cyg.	N	38°	5′	237
3	8	P XXI 1 Cyg.	N	29°	41′	238
4	1	γ Eq.	N	9°	37′	244
4	41	Σ 2769 Vulp.	N	21°	56′	306
8	10	δ Eq.	N	9°	29′	244
8	30	P XXI 51 Ceph.	N	59°	29′	227
9	20	α Eq.	N	4°	43′	244

Hour XXI.

m.	s.			PAGE
15	39	Σ 2790 Ceph.	N 58° 4′	227
16	4	1 Peg.	N 19° 15′	278
16	26	β Eq.	N 6° 15′	244
22	33	Σ 2799 Peg.	N 10° 31′	279
23	40	C 4670. M 15 Peg.	N 11° 35′	279
26	43	C 4678. M 2 Aquar.	S 1° 24′	200
26	55	β Ceph.	N 70° 0′	226
26	58	Σ 2804 Peg.	N 20° 8′	279
27	33	C 4681. M 39 Cyg.	N 47° 52′	239
28	::	* * Eq.	N 16° 5′	244
31	14	3 Peg.	N 6° 2′	278
32	59	C 4687. M 30 Capr.	S 23° 44′	222
34	56	P XXI 248 Ceph.	N 56° 54′	227
37	48	ε Peg.	N 9° 17′	278
37	53	Red * Cyg.	N 37° 25′	239
38	18	μ Cyg.	N 28° 10′	236
38	45	κ Peg.	N 25° 0′	278
38	59	Red * Cyg.	N 37° 13′	239
39	32	μ Ceph.	N 58° 11′	228
47	37	Σ 2840 Ceph.	N 55° 11′	227
51	31	Σ 2848 Peg.	N 5° 19′	279
55	20	29 Aquar.	S 17° 35′	199

Hour XXII.

m.	s.			
0	1	ξ Ceph.	N 64° 0′	226
2	50	Σ 2873 Ceph.	N 82° 15′	227
3	28	π^1 Peg.	N 32° 33′	278
4	0	P XXII 11 Ceph.	N 58° 39′	227
7	7	41 Aquar.	S 21° 43′	199
7	41	Σ 2883 Ceph.	N 69° 29′	228
8	0	Σ 2878 Peg.	N 7° 20′	279
10	10	C 4773. Ḫ VIII 75 Lac.	N 49° 14′	254
13	4	P XXII 65 Lac.	N 37° 7′	254
17	24	33 Peg.	N 20° 12′	279
19	29	53 Aquar.	S 17° 24′	199
22	7	ζ Aquar.	S 0° 41′	199
23	24	37 Peg.	N 3° 46′	278

Hour XXII.

m.	s.				PAGE
23	42	Σ 2913 Aquar.	S	8° 47′	200
24	20	δ Ceph.	N	57° 45′	226
25	56	7 Lac.	N	49° 37′	254
30	5	8^2 Lac.	N	38° 58′	254
36	14	P XXII 200 Aquar.	S	8° 59′	199
36	55	η Peg.	N	29° 33′	279
41	8	P XXII 219 Aquar.	S	4° 54′	200
42	43	τ^2 Aquar.	S	14° 17′	200
46	18	Σ 2950 Ceph.	N	61° 0′	227

Hour XXIII.

m.	s.				
1	14	P XXII 306 Peg.	N	32° 7′	279
3	45	π Ceph.	N	74° 41′	227
9	4	ψ^1 Aquar.	S	9° 48′	199
12	15	94 Aquar.	S	14° 10′	199
13	16	o Ceph.	N	67° 24′	227
18	30	C 4957. M 52 Ceph.	N	60° 53′	228
19	39	N 4964. ♅ IV 18 And.	N	41° 46′	196
24	2	P XXIII 101 Cass.	N	57° 50′	224
39	16	107 Aquar.	S	19° 24′	199
39	36	ψ And.	N	45° 43′	195
45	21	Σ 3042 And.	N	37° 10′	195
46	20	P XXIII 216 Peg.	N	11° 12′	279
50	36	C 5031. ♅ VI 30 Cass.	N	56° 0′	226
51	27	P XXIII 240 And.	N	23° 38′	194
51	49	R Cass.	N	50° 40′	225
52	25	σ Cass.	N	55° 2′	224
52	52	Σ 3050 And.	N	33° 0′	194
55	57	Σ 3053 Cass.	N	65° 23′	224

APPENDIX III.

TELESCOPIC OBJECTS IN THE SOUTHERN HEMISPHERE NOT INCLUDED IN THE BEDFORD CATALOGUE.

(From Sir J. F. W. Herschel's Observations at the Cape of Good Hope.)

The following selection of objects for students in S. Latitudes has been made without that personal knowledge, which is so important when an author's materials are to be adapted to a purpose not contemplated by himself; and this disadvantage will, it is hoped, be regarded in extenuation of defective and unequal execution. The arrangement is that of Right Ascension, without reference to constellations which in the Southern have not an equal claim to respect, on the ground of ancient custom, with those in the Northern hemisphere.

(A) DOUBLE STARS.

N.B.—All the data in the following list are mere approximations. The *numbers* are those of H, except a few supplied from the British Association Catalogue. Mean values have been taken, where he has not given them. General Epoch, 1870. Regard has been had in the selection to the S. D. U. K. Maps.

Name.	R. Asc.		Dec. S.		Pos.	Dist.	Mags.
	h.	m.	°	′	°	″	
β Toucani .	0	26	63	41	172	28	5, 5[a]
ξ Appar. .	0	27	35	42	164	6	6, 9
λ Toucani .	0	47	70	13	79	21	7, 8
3416 . .	0	58	60	47	127	5	8, 8
3447 . .	I	30	30	34	75	3	6, 7[b]
p (or 6) Erid.	I	35	56	51	122·3	3·65	6, 6[c]
ε Sculpt. .	I	40	25	42	70	6	6, 10
ω Fornac. .	II	28	28	57	242	11	5, 8
3527 . .	II	39	41	14	43	1½	7, 7
υ Fornac. .	II	43	37	57	151	8	6, 7
θ Erid. . .	II	53	40	50	81	9	5, 6[d]
12 Erid. .	III	7	29	30	310	5	3, 8[e]
f Erid. . .	III	44	38	1	200	9	5, 5[f]
θ Retic. .	IV	17	63	34	6	6	5, 9
3679 . .	IV	35	62	20	350	20	7, 12[g]

[a] Binary? [b] 1837.—83° : Jacob, 1846. [c] 1835.—250°·9 : 4″·88 : Powell, 1863. (+180°.) [d] Moving? Jacob, 1857. [e] Closing rapidly, Jacob, 1856. [f] Binary? Jacob, 1856. [g] 7 very high red.

Name.	R. Asc.		Dec. S.		Pos.	Dist.	Mags.
	h.	m.	°	′	°	″	
ι Pictor. . .	IV	48	53	41	58	12	5, 6
3752 . .	V	16	24	55	110	3	6, 9[a]
3760 . .	V	21	35	28	221 : 270	7 : 20	7, 7, 11
θ Pictor. . .	V	22	52	27	286	38	6, 6
3835 . .	VI	1	48	26	163	4	8, 8[b]
v Puppis. .	VI	35	48	6	317	13	5, 7
2207 B. A. C.	VI	38	38	16	276	8	6, 8
3928 . .	VII	1	34	35	158	5	6, 8[c]
2336 B. A. C.	VII	1	58	59	74·9	2·4	6, 7[d]
γ Volant. .	VII	10	70	17	301	13	5, 7
3945 . .	VII	11	23	2	68	28	6, 7
3966 . .	VII	20	37	2	141	7	7, 7
2477 B. A. C.	VII	24	31	35	52	10	6, 7
3973 . .	VII	26	20	40	36	8	9, 10[e]
n Puppis. .	VII	29	23	12	107	9	6, 6
k Puppis. .	VII	34	26	29	138	10	5, 5
4030 . .	VII	56	40	57	345	40	7, 9[f]
2753 B. A. C.	VIII	5	42	15	80	6	7, 8
γ Argûs . .	VIII	5	46	57	220 : 152	41 : 62	2, 6, 8
ε Volant. .	VIII	8	68	15	23	7	5, 10
2866 B. A. C.	VIII	25	44	18	350	6	6, 9
4104 . .	VIII	25	47	30	242 : 40	4 : 20	6, 9, 10
4128 . .	VIII	36	59	51	222	3	7, 8
4188 . .	IX	8	43	5	287	3	6, 7
ζ Antliæ . .	IX	25	31	12	211	8	6, 7
4220 . .	IX	29	48	17	202	3	6, 7
υ Argûs . .	IX	44	64	28	126	5	3, 8
3396 B. A. C.	IX	49	44	40	239	6	6, 10
T Velorum .	X	16	55	23	103 : 191	7 : 37	5, 10, 10
S Velorum .	X	26	44	24	38	14	6, 6
4383 . .	X	50	70	2	286	1½	7, 8
4432 . .	XI	18	64	15	288	2	6, 8
3907 B. A. C.	XI	22	41	57	167	13	6, 8
4455 . .	XI	30	32	51	245	4	6, 9
β Crater. .	XI	46	33	11	340	2	5, 5[g]
ε Chamæl. .	XI	53	77	29	178	1½	6, 6
4115 B. A. C.	XII	7	45	0	247	4	5, 7
α Crucis . .	XII	19	62	23	121 : 202	6 : 91	2, 2, 6[h]
γ Crucis . .	XII	24	56	23	38	120	2, 5[i]

[a] A 3rd star 107° : 60″ : 9. [b] In angular motion, and closing, Jacob, 1856-7-8. [c] Quadruple. [d] 1836.—78° : 3″ : Jacob, 1847. [e] Pure white, very remarkable brick red. [f] White, rich ruby coloured, approaching to sanguine. Very remarkable. [g] Binary : 338°·3, 1834 ; 342°·2, 1838. Not confirmed by Jacob.—(Not β, but 28, of S. D. U. K. Map.) [h] 1835.—118°·5 : 4″·98 : Powell, 1861 (blotchy, when α Cent. has clean discs.) [i] 36°·5 : 99″ : Powell, 1860.

Name.	R. Asc.	Dec. S.	Pos.	Dist.	Mags.
	h. m.	° ′	°	″	
γ Centauri .	XII 34	48 15	351	¾	4, 4[a]
4563 . .	XII 54	32 55	237	7	7, 9
θ Muscæ . .	XIII 0	64 37	187	6	6, 9
f Hydræ . .	XIII 30	25 50	191	10	6, 7
Q Centauri .	XIII 34	53 54	164	5	6, 7
k Centauri .	XIII 44	32 20	113	9	6, 7
4649 . .	XIV 0	58 6	64	12	9, 9[b]
Y Centauri .	XIV 13	57 51	163 : 2	10 : 35	6, 8, 11
α Centauri .	XIV 31	60 9	219·6	16·52	1, 2[c]
α Circini . .	XIV 32	64 15	244	16	4, 9
54 Hydræ .	XIV 38	24 54	134	9	6, 8
4715 . .	XIV 48	47 21	278	3	6, 7
π Lupi . .	XIV 56	46 33	111	¾	5, 5[d]
κ Lupi . .	XV 3	48 15	144	27	5, 6
4746 . .	XV 5	58 35			multiple[e]
μ^1 Lupi . .	XV 9	47 24	174 : 131	2 : 23	6, 6, 8
γ Circini . .	XV 13	58 51	108	1¼	5, 6
γ Lupi . .	XV 26	40 44	94	¾	4, 4
f Lupi . .	XV 27	44 31	349	3	5, 9
ξ Lupi . .	XV 49	33 36	49	11	6, 6
η Lupi . .	XV 51	38 2	22	15	4, 8
4848 . .	XVI 16	32 54	155	6	7, 7
4850 . .	XVI 16	29 24	348	8	6, 7
ε Normæ. .	XVI 18	47 16	335	24	5, 7
5 Ophiuchi .	XVI 18	23 9	2 : 2 : 287	4	6, 6, 8, 8[f]
4866 . .	XVI 29	56 44	126	4	7, 8
4876 . .	XVI 32	48 30	265	10	6, 7[g]
5700 B. A. C.	XVI 49	19 20	230	5	6, 8
4901 . .	XVI 50	58 39	134	3	8, 8
5827 B. A. C.	XVII 10	24 9	358	15	5, 6
4949 . .	XVII 17	45 43	267 : 313	3 : 104	6, 7, 7
5003 . .	XVII 51	30 14	107	6	6, 7[h]
5014 . .	XVII 58	43 24	69	¾	6, 6[i]
5041 . .	XVIII 15	53 42	260	2	7, 9
κ Coronæ .	XVIII 24	38 48	359	22	6, 7
γ Coronæ .	XVIII 58	37 15	37·1	2·66	6, 6[k]
β^1 Sagitt. .	XIX 13	44 42	79	29	4, 8

[a] 351° 35′, 1835·32; 357° 21′, 1836·38; a rapidly moving binary. Opening, Jacob, 1857. [b] 64°·4, 1835; 69°·4, 1837; probably binary, though measures precarious. Both stars *full scarlet*. [c] 1836. 'The most striking object of the kind in the heavens,' and the nearest to us yet known. Binary.—Orbit disturbed and period uncertain, Jacob.—5°·7 : 7″·85 : Powell, 1864 : period 76·25 y. [d] 112°·8, 1835; 108°·6, 1837. Binary. [e] Ten or more, 12 or 13 mag. within 45′ of an 8 mag. Rare. Another is in XVII^h 26^m, 32° 30′. [f] On intensely black ground, in great blank space. [g] Two companions, 13 and 14 mag. [h] Moving? Jacob. [i] Rapid binary? Jacob. [k] 1834.—Closing, 1858 : period about 100 y. Jacob.—318°·1 : 1″·25 : Powell, 1863.

Name.	R. Asc.	Dec. S.	Pos.	Dist.	Mags.
	h. m.	° ′	°	″	
6782 B. A. C.	XIX 42	55 18	151	23	6, 7
7191 B. A. C.	XX 41	62 55	101	3	7, 7
θ Indi . .	XXI 10	54 0	307	4	5, 10[a]
λ Octant. .	XXI 31	83 19	83	3	6, 9
β Pisc. Aust.	XXII 24	33 1	173	29	4, 8
γ Pisc. Aust.	XXII 45	33 33	277	4	4, 10
8046 B. A. C.	XXIII 0	51 23	260	8	6, 7
Σ 2988 . .	XXIII 4	12 37	100	3	7, 7
ψ Gruis . .	XXIII 16	54 32	213	27	6, 7
θ Phœnic. .	XXIII 32	47 21	269	4	6, 7
[γ^1, γ^2 Arg. .	must, according to Map, be a splendid open pair.]				

[a] Jacob, angular motion? Russell 292°, 1871.

(B) RED STARS.

R. Asc.	Dec. S.	Mag.	H's Description.
h. m.	° ′		
I 21	33 13	6	Most beautiful orange red.
V 40	46 31	8	Vivid sanguine red, like a blood-drop. A superb specimen of its class.
VI 18	26 58	8	Very intense ruby.
VII 18	25 31	7	Very intense fiery red.
VII 42	31 49	9	Very fine ruby.
IX 29	62 13	8	Very intense sanguine.
IX 50	40 58	7·5	Scarlet; remarkably full rich colour.
X 6	34 41	7	Scarlet.
X 29	38 54	6·5	Extreme orange, almost scarlet.
XI 5	81 5	8	Ruby, almost sanguine.
XI 34	71 51	8·5	Fine ruby, inclining to scarlet.
...	...	...	In field with β *Crucis*, the fullest and deepest maroon red. H's most intense; like a drop of blood, when contrasted with β, 8·5m.
XV 2	69 35	6	Almost scarlet.
XV 12	75 27	7	Very high red.
XVI 32	32 7	8	Deep red, like a drop of blood.
XVII 31	41 33	8	Beautiful ruby red.
XIX 59	27 36	7·5	Fine ruby.
XX 20	28 41	8	Fine ruby.

(190 Argûs, about $\text{VII}^h\ 34^m$, $37°\ 30'$, is mentioned by Freeman as a singularly red star in a fine field.)

We may place here that most wonderful variable, η Argûs ($x^h\ 40^m$, $59°\ 0'$), whose changes have attracted so much attention of late years. 1677, 4m. 1751, 2m. 1811–15, 4m. 1822–26, 2m. 1827, 1m. 1828–33, 2m. 1838–43, 1m. 1843–50, nearly or quite equal to Sirius, with some strange fluctuations, 1845–48. Lost to nearly all eyes, 1862, or as others 1864. 1865, 5m.—Wolf thinks a period possible of 46 y. with two subordinate *maxima* and *minima*.—Loomis prefers 70 y.—Le Sueur, with the great Melbourne reflector, finds its spectrum crossed by bright lines.

This star was seen by H, 1838, encompassed by dense nebulosity. 1860–62, Powell noticed it much fainter and changed in form. 1863, Abbott found its shape quite altered, and still further 1865, with changed colours in some neighbouring stars. Proctor, however, considers this a mistake, arising from wide difference of scales.

Canopus was thought, 1861, in Chili, brighter than Sirius. (*Astron. Nachr.* 1311.)

ϵ Crucis. Lettsom, 1860, found this star 6m. instead of 4m. as in Map.

(C) CLUSTERS AND NEBULÆ.

The two Magellanic Clouds, or Nubecula Major and Minor, are of the most complex nature:—large tracts of nebulosity, irresolvable and in every stage of resolution, with clustering groups, nebulæ of all kinds, globular clusters, and nebulous objects of unique character. The N. Major contains 278 clusters and nebulæ, with 50 or 60 outliers; the Minor 37, with 6 adjacent. They combine what are elsewhere strikingly separated, the galactic and the nebular system.

The Galaxy from Centaurus to Argo was all resolvable on a dark ground with H's 18¼-inch specula, front view.

The numbers in the following list are those of H's 'General Catalogue.'

No. in Gen. Cat.	R. A.	Dec. S.	
	h. m.	° ′	
52	0 18	72 52	Most glorious globular cluster; stupendous object; completely insulated: stars all nearly 12—14m. Central blaze ruddy, rest white. 47 Toucani, *p Nubec. Minor.*
138	0 41	26 4	Very bright large neb. 24′ × 3′.
162	0 46	27 21	Bright cl. 5′ diam. 12—16m.
165	0 47	74 7	Centre of *Nubec. Minor*, a partially resolved cloud, 11—18m. in a most barren region.
183	0 52	73 14	Bright knot of 13—15m. stars.
193	0 58	71 36	Cl. 13—14m.; central blaze.
361	I 28	30 8	Bright large neb.
697	III 17	37 44	Bright neb.; stellar nucleus, 2″.

No. in Gen. Cat.	R. A.		Dec. S.		
	h.	m.	°	′	
731	III	28	36	36	Very bright nucleus, resolvable? between two lengthened parallel clouds of haze.
744	III	32	35	58	Bright cl.
748	III	33	35	55	Ditto, resolved?
752	III	34	19	2	Bright neb.
769	III	38	36	34	Bright cl.
808	III	59	43	44	Cl. just N. of great group of large stars, 6—8m.
982	IV	57	66	37	Bright large neb. (from this to 1350 inclusive, all, except 1328, are in *Nub. Maj.*)
1009	V	0	38	11	Ditto, resolvable?
1031	V	4	66	37	Bright cl.
1032	V	4	67	27	Cl. in radiating streaks.
1060	V	9	68	56	Fine large cl. 13m.
1061	V	9	40	12	Superb cl. 14—16m.; central blaze.
1065	V	10	69	1	Bright cl. 12m.
1079	V	14	67	32	Large cl.
1109	V	18	68	44	Ditto.
1181	V	29	66	20	Large oval neb.
1207	V	31	67	23	Cl. 12—14m.
1220	V	33	17	56	Fine group.
1230	V	35	67	0	Large cl. 9—11m.
1269	V	40	69	10	'Great looped neb.' round 30 Doradûs, in *Nub. Maj.* visible to naked eye: Le Sueur gaseous.
1298	V	43	69	16	Cl. 13—16m.
1328	V	53	59	56	Group of bright and smaller stars.
1350	V	59	69	12	Bright cl.
1404	VI	17	44	42	Cl. coarse, brilliant; chief, 8m.
1513	VII	13	24	42	Fine cl.; 8′ diam.
1543	VII	25	16	54	Brilliant group, 8—10m.
1573	VII	40	37	38	Very large bright cl.; one 4·5m. orange.
1593	VII	47	38	11	Beautiful large cl. 12 or 13m.
1598	VII	49	23	56	Very rich milky-way cl. 10—12m.
1619	VII	56	60	29	Large brilliant cl. 7—13m.; orange star in middle. Visible to naked eye.
1636	VIII	7	48	51	Ditto, 7—16m.
1783	IX	7	41	52	Plan. neb. 6″ diam. bright as 9m.
1793	IX	9	64	17	Superb cl. 13—15m., 'like the finest dust;' central blaze.
1801	IX	10	36	2	Cl. containing neb. nearly plan. like M 46 (Argûs, *antea*).
1843	IX	17	57	43	Plan. neb., perfectly sharp and round; 8″; white.
1881	IX	30	46	19	Very large cl. from 8m. 'Telescopic Præsepe.'
2007	IX	58	59	27	Very large loose cl. 9—14m.
2017	X	1	39	45	Plan. neb. large; elliptic; enclosing star 9m.

No. in Gen. Cat.	R. A.	Dec. S.	
	h. m.	° ′	
2197	X 40	58 57	Great diffused branching milky neb. with interior darkness, about η Argûs [probably gaseous].
2308	XI 1	57 55	Glorious cl. 8—12m. Most brilliant H had ever seen.
2468	XI 30	60 50	Large cl. 8—13m. 150 to 200 stars.
2573	XI 43	47 29	Ditto, 9—14m.
2581	XI 43	56 24	Plan. neb. 12″; beautiful rich blue; bright as 7m.
3128	XII 32	25 59	M 68. Cl. 12m.
3275	XII 45	59 35	Vivid and beautiful cl. 50 to 100, of various colours, some greenish, round κ Crucis, extremely red. Abbott (1862) suspected changes in number, position, and colour.
3466	XIII 8	62 40	Great milky-way cl. 34, 11m. 150 or 200 smaller.
3531	XIII 18	46 35	'Most glorious object;' cl. of full 20′, thousands of stars of 2 mags. 12 and 13 only (or 13 and 15); perhaps from optical coincidence; the larger like lace-work; two darker spaces in centre. Hazy 4 or 5m. star to naked eye, ω Centauri.
3922	XIV 25	55 57	Bright cl. 9—13m. 7m. red or yellow, central.
4066	XV 7	45 8	Plan. neb., most elegant and delicate; perfectly sharp; 4″; white.
4100	XV 17	54 2	Cl. 11—14m., in pairs and small groups, on a black ground.
4153	XV 52	60 6	Brilliant cl. from 7m.
4162	XVI 2	53 51	Superb cl. 20′; 10—15m.
4170	XVI 7	57 33	Coarse brilliant cl. 7—10m.
4184	XVI 16	40 20	Cl. 50 or 60, 9—11m.
4261	XVI 52	29 54	M 62. Superb cl. 7′; 14—16m.
4307	XVII 26	44 39	Cl. 4′; 17—20m., excessively close.
4318	XVII 31	32 7	M 6. Cl. 7—10m.
4332	XVII 41	37 0	Cl. 18—20m., central blaze. γ Telesc. in field.
4340	XVII 45	34 47	M 7? Brilliant cl. 60, 7—12m.
4411	XVIII 22	32 27	M 69. Cl. 14—16m.
4428	XVIII 34	32 25	M 70. Cl. 14—17m.
4442	XVIII 46	30 38	M 54. Cl. 15m.
4503	XIX 31	31 16	M 55. Cl. 12—15m.

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